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THE METHYLENE BLUE REDUCTION TEST: ITS EFFICIENCY AND INTERPRETATION UNDER PHILIPPINE CONDITIONS.[1]

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ONE TEXT FIGURE

Sanitarians have long recognized that the bacterial content of milk is one of the most important criteria of the quality and cleanliness observed in its production and subsequent handling. Several methods have been devised for estimating the bacterial content of milk. Among the bacteriologic methods described by the American Public Health Association is the "methylene blue reduction method," also known as the "reductase test."

This test is a biochemic one and is based on the fact that the color imparted to milk by a small quantity of methylene blue will in time disappear, due, mainly, to the action of bacteria present. Formerly it was believed that there was a more or less direct relationship between the rate of decolorization and the number of bacteria; that is, the fewer the bacteria, the longer the time necessary for decolorization. Later researches, however, revealed that this is only partially true.

Due to the simplicity and ease of applying and interpreting the methylene blue reduction test, together with the comparatively simple equipment required, should this test be found efficient under local conditions, it is likely that it will be as widely used here as it is in Europe and, to some extent, in the United States and Canada.

[1] Read at the Third Philippine Science Convention, February 27, 1935.

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REVIEW OF THE LITERATURE

About ten years after Caro's discovery (Hall, 1921) of methylene blue in 1876, that dye gained popularity as an indicator of biochemic reduction through Ehrlich's (1885) study of "the combined velocity, capacity and intensity factors of biological reduction." In 1894 Duclaux studied the reduction of dyes with special reference to milk and found that milk subjected to bacterial action becomes reducing. Neisser and Wechsberg in 1900 suggested that the reduction of methylene blue might be used as an indication of the bacterial content of milk.

Barthel and Orla-Jensen originally prepared the methylene blue solution by suitable dilutions of a saturated alcoholic solution of the dye. Later, they recommended (1912) the use of prepared tablets containing a standard amount of methylene blue. Russell, Morrison, and Ebling (1925) cited Weber, who found that the methylene blue powder obtained from different sources varies considerably in strength, while the prepared tablets are sufficiently uniform for practical purposes. The "Standard Methods" (1934) recommends the use of prepared tablets. Thus the necessity of expensive chemical balances is eliminated and all workers are enabled to use a uniform reagent and to obtain comparable results. The standard concentration of the dye used in this test is 1 part of dye to 200,000 parts of milk.

Up to a few years ago the conception of the phenomenon of methylene blue reduction in milk was that it was due to an enzyme, reductase, hence it was called the "reductase test." Jensen (1907) concluded that the peroxidase of cow's milk comes exclusively from the mother cow, presumably from the fodder; the catalase, partly from the leucocytes of the mother cow and to a large extent from the microörganisms; but that the reductase of fresh milk ("Aldehydkatalase") comes exclusively from the fat globules ("Milchkügelchen"). However, Trommsdorf (1909) found that freshly drawn milk free from bacteria contains no reductase. Subsequently, Rullmann (1910) in a study of eighty-one aseptically drawn milks concluded that reductase, hydrogenase, and other enzymes found in cow's milk

are of bacterial origin. Burri and Kürsteiner (1912) also concluded that, as a rule, besides bacteria there is no other reducing factor in normal raw milk. Fred (1912), moreover, found that bacterial development and time of reduction are related inversely to a certain degree and that the reductases are formed only by the growth of microörganisms and are therefore absent in milk when first drawn. He also thinks that very probably both intracellular and extracellular products take part in the reduction.

However, the phenomenon of dye reduction in sterile milk (Barthel, 1917), and other bacteriologic media (Dubos, 1929), cannot be satisfactorily explained by the bacterial enzyme theory of reduction. Recent studies (Thornton and Hastings, 1929) on the potential-time curves further demonstrated the weakness of this theory. Barthel and, later, Hastings (1919) suggested that the reduction of methylene blue might be due to some constituents of the milk.

Barthel (1917) believed that the disappearance of methylene blue in milk takes place in two stages; namely, (*a*) the removal of the dissolved oxygen by the bacteria and (*b*) the reduction of the dye by constituents of the milk. Thornton and Hastings (1929, *a;* 1930) confirmed this theory of Barthel and also found that the time taken for the first stage may be long, while for the second stage it is usually short. They also confirmed the findings of Hastings and his associates (1922) that a preliminary shaking of the milk does not materially affect reduction time, contrary to the findings of Lojander (1925), which show that shaking the milk thirty times results in a lengthening of the reduction times. The findings of Marshall (1902) indicate that there are some variations in the oxygen content of different milks as received at the milk plant. However, Thornton and Hastings (1930), judging from their experiments, believe that the differences in the oxygen content of milk samples produced in the ordinary way apparently will not introduce serious inaccuracies into the test. On the other hand, they assumed that the two important inaccuracies of this test are due to (*a*) the rate of oxygen uptake by the milk bacteria and (*b*) the removal of bacteria from the body of the milk by the rising butter fat. The original literature gives more-detailed information on these points.

Within the last few years the phenomenon of dye reduction was studied from an entirely different angle since Gillespie (1920) showed that the reducing intensity of bacterial cul-

tures is measurable by potentiometric methods. The recent studies of Clark and his associates (1928), Coulter (1928), Thornton and Hastings (1929), Cohen (1931), Frazier and Whittier (1931), Fay and Aikins (1932), and others have necessitated a revision of the older views as to the meaning of dye reduction in milk, this time in terms of the electronic concept of oxidation-reduction phenomenon.

Hewitt (1933) published an interesting review of the recent advances made in the study of oxidation-reduction reactions. In the light of the present knowledge, biologic oxidation reactions are considered as "electronic rearrangements" or "electronic migrations" involving exchanges of electric charges. The migration of hydrogen or oxygen atoms is regarded as "merely incidental to the maintenance of electrical neutrality." Since oxidation and reduction reactions involve exchanges of electric charges, they readily lend themselves to an exact quantitative study by electrode potential measurements. In terms of physical chemistry, "the more highly oxidized a substance is the higher will be the electrode potential, and the more reduced, the more negative." The intensity level of the oxidizing or reducing functions of substances is determined by the readiness with which they part with, or take up, electrons. The expression "electrode potential," or Eh, is a measure of intensity level and is "dependent on the ratio of oxidized and reduced forms of the substance studied and not on their absolute quantities." The most reliable method of measuring Eh is the direct electrometric determination of the potential. However, certain dyes, like methylene blue, which change color at different ranges of Eh, may also be used as oxidation-reduction potential indicators. Methylene blue has always been considered as the indicator par excellence in the reduction test for milk.

Fay and Aikins (1932) have aptly said, "The methylene blue reduction test as it is used today is one of the most practical tests for determining the quality of milk. Although the early conceptions of biological processes have been completely reorganized, the selection of the dye and the concentration employed have not been changed by a more fundamental understanding of the factors involved."

Orla-Jensen (1931, pp. 184–191) states that this test is widely employed in milk-control work in Scandinavian countries. According to Mudge (1927), this method has found considerable support also in other parts of Europe. Fay (1930)

states that this test has met with great popularity in the United States. Thornton and his associates (1934) report that the methylene blue reduction test is used extensively with considerable success in Alberta Province, Canada, and that it measures the bacterial content of a great many of the milks arriving in Edmonton more accurately than does the plate count.

In practice the methylene blue reduction test is divested of some technicalities in order to make it simpler and more practical. Instead of the 10-cc pipettes, 10-cc dippers and graduated test tubes have been introduced for measuring the milk samples. Sterility of the apparatus and reagent is not considered by some as essential. Thornton and Hastings (1930) consider the 10-cc dipper sufficiently accurate; they have shown (1929, *a*) that a concentration of 1 part dye to 200,000 parts milk gives approximately the same results as a dye concentration of 1: 100,000. They also concluded that, in routine work, sterility of the dipper or the dye solution is not necessary if the reduction times are not read after five and a half hours; also, any water fit for drinking can be used as a solvent for the dye. Fay (1930) also came to the conclusion that the various modifications designed to simplify the test do not seriously affect its interpretative value. However, he calls attention to the necessity of observing great care in measuring the methylene blue solution as gross errors in its measuring may impair the accuracy of the test.

The time required for decolorization in this test has been empirically correlated with the number of bacteria present, and according to Orla-Jensen (1931, pp. 184–191) the following scheme of classification is used in the Scandinavian countries:

Class I. Good milk, not decolorized in five and a half hours, developing as a rule, less than one-half million colonies per cc on agar plates.

Class II. Milk of fair average quality, decolorized in less than five and a half hours but not less than two hours, developing as a rule, one-half to four million colonies per cc on agar plates.

Class III. Bad milk, decolorized in less than two hours, but not less than twenty minutes, developing as a rule, four to twenty million colonies per cc on agar plates.

Class IV. Very bad milk, decolorized in twenty minutes or less, developing as a rule, over twenty million colonies per cc on agar plates.

In "Standard Methods" (1929), where the report of Bolling (1924) was cited, it is hinted that, under American conditions, the above classification is apparently working out fairly well.

So far as the writer is aware, there is no published work on this subject in the Philippines.

OBJECT OF THE PRESENT WORK

The object of the work here reported was to determine the efficiency of the methylene blue reduction test and the applicability of the Scandinavian method of interpretation of this test under local conditions. Carabao milk was used because the carabao is our principal source of milk in the provinces, where tests of this nature would be most applicable, owing to the absence of proper laboratory facilities. Moreover, the carabao's habit of wallowing in the mud, together with the all too prevalent neglect on the part of the milkman to observe sanitary precautions, are likely to result in milk contamination by forms of bacteria other than those normally found in cow's milk.

MATERIALS AND METHODS

Milk samples.—Carabao milk only was used in this experiment. The samples of milk were bought from different milkers in the barrios of Alabang and Cupang in the municipality of Muntinlupa. One hundred forty-two samples bought from 36 milkers were examined. They ranged in age from one to two hours at the time of the test. They were not refrigerated but were examined immediately upon arrival in the laboratory. From 8 to 12 samples were examined each time. The tests were performed twice a week.

Methylene blue solution.—Methylene blue tablets manufactured by the National Aniline and Chemical Company were used. Several 500-cc bottles, each containing 200-cc of glass-distilled water, were sterilized at 20 pounds for thirty minutes and then closed with sterile rubber stoppers. Several 300-cc beakers, covered with Manila paper, were also sterilized in the same way.

The day previous to the test about 50 cc of the sterile distilled water was poured into a sterile beaker and boiled and one methylene blue tablet dropped into it and dissolved. The remainder of the distilled water in the bottle was then added to the hot dye solution. This gave a 1:200 solution. When the solution had cooled, it was poured into the sterile bottle and tightly stoppered. A fresh solution of methylene blue was prepared for each batch of samples to be examined.

Apparatus.—Standard 1-cc (subcalibrated into hundredths of a cubic centimeter) and 10-cc pipettes were put in separate

metal containers. Standard Petri dishes were individually wrapped in paper. The test tubes were plugged with cotton. All of these were sterilized in the hot-air sterilizer at 175° C. for one hour. Several rubber stoppers for the test tubes were also wrapped in paper and sterilized with the dilution bottles at 20 pounds pressure for thirty minutes in the autoclave.

Medium.—The nutrient agar was prepared according to the standard method. Witte peptone and commercial agar (*gulaman*) were used. The agar was previously soaked and washed in distilled water and drained. The medium was clarified, dispensed in 10-cc amounts in test tubes, and sterilized at 15 pounds for twenty minutes. The pH value, after final sterilization, was 6.8.

EXPERIMENT

Each sample of milk was examined by the methylene blue reduction method and by the Petri plate, or standard plate method. In order to determine the efficiency of the reduction test, five such tests (*a*, *b*, *c*, *d*, and *e*) were performed at the same time from each sample. The object of this phase of study was to find out if replicate tests of the same sample will decolorize at the same time; if not, whether such variations will affect the interpretative value of the test. To ascertain whether the Scandinavian scheme of interpretation of this test will work well under local conditions, the standard plate method was also used with each sample. Since the standard plate method requires more time to perform, each sample was examined by that method first, followed immediately by the methylene blue reduction test. In this way the two tests were performed on each sample within five minutes of each other. Thus, the bacteria did not have much chance to multiply. These tests were all made in a closed room in order to minimize chances of contamination from outside sources. The technic employed was in accordance with the "Standard Methods" (1934).

STANDARD PLATE METHOD

The sample was shaken vigorously and then dilutions of 1 : 100, 1 : 1,000, 1 : 10,000, and 1 : 100,000 were made and plated. The dilution bottles were also vigorously shaken before each plating and further dilution. Ten cc of melted nutrient agar at a temperature of 40° C. was used for each Petri dish. The diluted milk sample and the medium in the Petri dish were thoroughly mixed and then allowed to harden. When the agar had solidified, the plates were inverted and incubated

at 37° C. for forty-eight hours. The dishes were piled in stacks of three, with about an inch space between piles. A water-jacketed type of incubator was used. The counts were made on plates containing from 30 to 300 colonies. The colonies were individually counted with the aid of a hand lens. Control plates were also incubated to check the sterility of the nutrient agar, glassware, and diluting fluid used.

THE METHYLENE BLUE REDUCTION TEST

By means of a sterile pipette, 10 cc of each sample of milk was placed in each of five sterile plugged tubes, with the necessary aseptic precautions. The sample bottle was shaken vigorously before drawing the sample. One cc of the dye was then added to each tube. The cotton plug was replaced by a sterile rubber stopper and the test tube inverted gently to mix the dye and milk thoroughly. The milk assumed a robin's egg blue color. No dye was added to an extra tube containing 10 cc of milk to serve as control. The time was recorded, and the tube immediately placed in a 37° C. water bath. The tubes were then transferred to separate containers and put in a 37° C. incubator. Observation was made at frequent intervals (not longer than five minutes) until the milk regained its normal color as compared with the control tube, when the time was again recorded. The samples that were about to decolorize were observed more closely so that the closest approximate time of decolorization could be recorded. In cases where the color did not disappear uniformly the tubes were inverted gently to mix the dye. When the color disappeared after mixing, the tube was discarded and the time recorded. If the color persisted the tube was again returned to the incubator for further observation. The incubator was always maintained at 37° C.

RESULTS AND DISCUSSION

THE EFFICIENCY OF THE METHYLENE BLUE REDUCTION TEST

Table 1 shows the efficiency of the methylene blue reduction test as performed on 142 samples of carabao milk, five parallel tests (*a*, *b*, *c*, *d*, and *e*) to each sample. Of the 21 samples belonging to class I, 18 decolorized simultaneously in replicate tests and are designated as "uniform samples." This gives a frequency of occurrence of 85.71 per cent. Only 3 samples, or 14.28 per cent, of the class I samples did not decolorize simultaneously and are designated "erratic samples." Samples

of classes II, III, and IV are similarly recorded. Of the 64 samples examined under class II, 62, or 96.87 per cent, were uniform samples and 2, or 3.12 per cent, were erratic. There were 47, or 97.91 per cent, uniform samples of the 48 class III samples and 1, or 2.08 per cent, erratic. There was no erratic case in the 9 class IV samples examined. The great difficulty experienced in obtaining samples belonging to class IV would not permit the examination of a greater number of samples.

The actual decolorization data of the erratic samples are also given. Column 9 gives the decoloration times of each of the five tubes in each sample in replicate tests. Examination of the entire column shows a variation of from one to ninety minutes between replicate tests of the same sample. However, despite these variations, all the tubes in the replicate tests for each sample, except those of sample S–78 of class III, decolorized within the decolorization time limit set for the class to which the sample belongs. In the case of sample S–78 no great injustice would probably be done to the milker if it were classified as class IV instead of class III. Thornton and Hastings (1930) found that except in very rapidly reducing milks it is difficult to read the end point, in many cases to within five and even ten and fifteen minutes, and that it was simply guess work after twenty-three hours. For the same reason Johns (1931) in his investigation disregarded variations of less than fifteen minutes. This difficulty was greatly obviated in the present study by comparing the samples tested with the control. However, the extra precautions observed notwithstanding, the end-point readings herein reported cannot be claimed to be accurate to the minute and for practical purposes a difference of five minutes in replicate tests can be regarded as insignificant. The mean and the deviation from the mean of each erratic sample are given in columns 10 and 11, respectively, for purposes of comparison.

The variation in reduction time for the replicate tests on the same sample of milk was calculated and recorded in columns 12 and 13 as standard deviation and coefficient of variability, respectively. Although the data for each sample from which these statistical constants were computed are rather inadequate (five), yet it will give us a better idea of the reliability of the test. For example, in the case of sample S–23, three times its standard deviation, 36, on either side of its mean, 252, will include all possible variates. The coefficient of variability ranges from 0.66 to 14.28 per cent.

TABLE 1.—*The efficiency of the reductase test.*

Class (Scandinavian method).	Samples examined.	Uniform samples.		Erratic samples.								
						Decolorization data.						
		Samples.	Frequency occurrence.	Samples.	Frequency occurrence.	Sample No.	Tube.	Decolorization time.	Mean.	Deviation from the mean.	Standard deviation.	Coefficient of variability.
			Per cent.		*Per cent.*			*min.*	*min.*	*min.*		
							a	335		— 5		
							b	335		— 5		
						S-162	*c*	335	340 ± 3.37	— 5	10 ± 2.13	2.94 ± 0.627
							d	360		+20		
							e	335		— 5		
							a	365		—11		
							b	365		—11		
I	21	18	85.71	3	14.28	S-110	*c*	420	376 ± 6.61	+44	22 ± 4.69	5.85 ± 1.247
							d	365		—11		
							e	365		—11		
							a	384		— 2		
							b	384		— 2		
						S-1	*c*	389	386 ± 0.81	+ 3	2.45 ± 0.52	0.66 ± 0.140
							d	389		+ 3		
							e	384		— 2		

II	64	62	96.87	2	3.12	S-9	*a*	200	198 ± 0.81	+ 2	2.45 ± 0.52	1.23 ± 0.262
							b	200		+ 2		
							c	195		3		
							d	200		+ 2		
							e	195		— 3		
						S-23	*a*	270	252 ± 12.14	+18	36 ± 7.67	14.28 ± 3.045
							b	180		—72		
							c	270		+18		
							d	270		+18		
							e	270		+18		
III	48	47	97.91	1	2.08	S-78	*a*	23	21 ± 0.68	+ 2	1.48 ± 0.81	7.04 ± 3.045
							b	23		+ 2		
							c	18		— 3		
							d	19		— 2		
							e	22		+ 1		
IV	9	9	100.00	0	0.00				0.00		0.00	0.00
For all classes	142	136	95.77	6	4.15							

In general the data obtained agree with the conclusions reached by Fay (1930) that the methylene blue reduction tests are characterized by a low degree of variability and in replicate tests the maximum and the minimum reduction time for each sample are relatively close together. Fred and Chappelear (1911) observed a remarkable uniformity in the time of reduction of parallel tubes in this test. Johns is of the opinion that the variations encountered up to ten hours are not of sufficient magnitude to warrant placing the upper limit of accuracy below this point. The results presented in Table 1 also closely agree with the findings of previous investigators (Thornton and Hastings, 1930; Fay, 1930; Johns, 1931) that variations between replicate tests increase with increased reduction time.

TABLE 2.—*Decolorization time and standard plate count of class I samples of milk.*

Sample No.	Decolorization time.	Standard plate count.	Sample No.	Decolorization time.	Standard plate count.
	min.	*Bacteria per cc.*		*min.*	*Bacteria per cc.*
S-29	330	174,000	S-85	348	62,000
S-65	330	317,000	S-26	350	315,000
S-137	330	250,000	S-79	368	95,000
S-62	333	134,000	S-110	376	346,670
S-55	337	143,000	S-34 [a]	377	1,850,000
S-95	337	220,000	S-1	385	495,000
S-168	338	130,000	S-151	393	89,700
S-40	340	310,700	S-130	400	265,000
S-162	340	106,670	S-116	420	125,000
S-66	342	300,000	S-17	427	400,000
S-58	346	216,000			

[a] Erratic sample.

From the bottom of Table 1 it may be seen that of the 142 samples examined, 135, or 95.77 per cent, decolorized simultaneously in replicate tests and that only 6, or 4.15 per cent, decolorized at different times.

The above results clearly demonstrate the reliability of the methylene blue reduction test even when only one test is made for each sample. Although variates are likely to occur in replicate tests of the same sample, these variates are relatively so close together that they are all likely to fall within the same class.

TABLE 3.—*Decolorization time and standard plate count of class II samples of milk.*

Sample No.	Decolorization time.	Standard plate count.	Sample No.	Decolorization time.	Standard plate count.
	min.	*Bacteria per cc.*		*min.*	*Bacteria per cc.*
S-47	120	986,000	S-25	175	3,535,000
S-6 [a]	127	400,000	S-61	177	750,000
S-20	127	1,160,000	S-109	180	500,000
S-21	130	600,000	S-36 [a]	180	400,000
S-78	130	2,225,000	S-96 [a]	181	200,000
S-83	131	1,160,000	S-42	183	1,190,000
S-80	133	870,000	S-165 [a]	184	200,000
S-56	135	1,240,000	S-32	188	1,365,000
S-8	135	1,405,000	S-138	196	875,000
S-76	138	1,890,000	S-9	198	525,000
S-64	144	1,465,000	S-143	199	500,000
S-60	150	1,115,000	S-149	200	1,130,000
S-77	150	2,200,000	S-86	216	2,145,000
S-75	152	2,480,000	S-146	217	715,000
S-41	153	4,400,000	S-91	219	800,000
S-45	153	1,720,000	S-53	222	1,770,000
S-90	153	565,000	S-19	227	640,000
S-37 [a]	155	89,300	S-46 [a]	229	9,200,000
S-54	155	510,000	S-150	232	805,000
S-177 [a]	155	495,000	S-35	236	1,715,000
S-10 [a]	157	4,050,000	S-15	238	600,000
S-2	157	785,000	S-106 [a]	239	410,000
S-135	160	965,000	S-23	252	600,000
S-79	160	1,830,000	S-33	255	850,000
S-5 [a]	163	222,330	S-133	266	535,000
S-48 [a]	166	400,000	S-70 [a]	289	225,000
S-142	168	1,095,000	S-164	291	685,000
S-24	168	780,000	S-11	292	500,000
S-88	169	1,645,000	S-43	296	1,360,000
S-18	170	2,070,000	S-44	301	785,000
S-140	172	785,000	S-172	301	500,000
S-89 [a]	173	410,000	S-22	320	555,000

[a] Erratic sample.

THE SCANDINAVIAN METHOD OF INTERPRETATION

Tables 2, 3, 4, and 5 show the decolorization time and standard plate count of milks of classes I, II, III, and IV, respectively. The samples in each table are arranged in the ascending order of their approximate decolorization time. In the case of those samples that did not decolorize simultaneously in replicate tests, the mean decolorization time as shown in

TABLE 4.—*Decolorization time and standard plate count of class III samples of milk.*

Sample No.	Decolorization time.	Standard plate count.	Sample No.	Decolorization time.	Standard plate count.
	min.	*Bacteria per cc.*		*min.*	*Bacteria per cc.*
S-3 [a]	21	1,855,000	S-171 [a]	44	660,000
S-73	21	4,300,000	S-117	45	4,145,000
S-157	24	10,700,000	S-154	46	4,065,000
S-105 [a]	25	1,910,000	S-97 [a]	48	1,140,000
S-178 [a]	26	3,300,000	S-120 [a]	50	3,675,000
S-192 [a]	26	495,000	S-167 [a]	50	905,000
S-113	26	11,000,000	S-84	52	7,100,000
S-87	30	6,345,000	S-139 [a]	52	1,265,000
S-114	30	5,195,000	S-4 [a]	58	1,929,000
S-123 [a]	34	2,410,000	S-104	62	5,400,000
S-173	34	4,000,000	S-166	67	4,500,000
S-14 [a]	35	42,020	S-145 [a]	70	1,045,000
S-181 [a]	38	1,700,000	S-107	70	5,500,000
S-127	39	5,700,000	S-159	73	8,100,000
S-144	39	16,800,000	S-74 [a]	74	395,000
S-102 [a]	40	1,720,000	S-158 [a]	75	1,765,000
S-156	41	5,200,000	S-175	78	5,200,000
S-122 [a]	42	1,555,000	S-124 [a]	83	1,270,000
S-112	42	6,020,000	S-116 [a]	84	279,300
S-100 [a]	43	1,690,000	S-49 [a]	94	875,000
S-93	43	4,000,000	S-128	96	4,220,000
S-99	44	6,200,000	S-67	98	4,430,000
S-12	44	4,100,000	S-51	100	4,200,000
S-119 [a]	44	2,380,000	S-83 [a]	100	360,000

[a] Erratic sample.

TABLE 5.—*Decolorization time and standard plate count of class IV samples of milk.*

Sample No.	Decolorization time.	Standard plate count.	Sample No.	Decolorization time	Standard plate count.
	min.	*Bacteria per cc.*		*min.*	*Bacteria per cc.*
S-31	5	20,200,000	S-136 [a]	14	14,100,000
S-25	5	60,700,000	S-143	15	22,300,000
S-60	6	86,800,000	S-72 [a]	17	5,715,000
S-71	10	25,300,000	S-7	20	34,900,000
S-39 [a]	12	8,820,000			

[a] Erratic sample.

Table 1 was taken as the decolorization time of the sample. The standard plate counts herein reported are the averages of at least two counts. The conventional method of reporting plate counts (Kolmer and Boerner, 1931, p. 409), which con-

siders only two significant left-hand digits, was disregarded and the actual count recorded so that a more accurate coefficient of correlation between the decolorization time and the standard plate count may be obtained. The results of the two tests on 142 samples of milk are also shown in text fig. 1. The standard plate counts are indicated logarithmically as ordinates of the dot diagram and the decolorization times in minutes are represented as abscissæ with natural numbers.

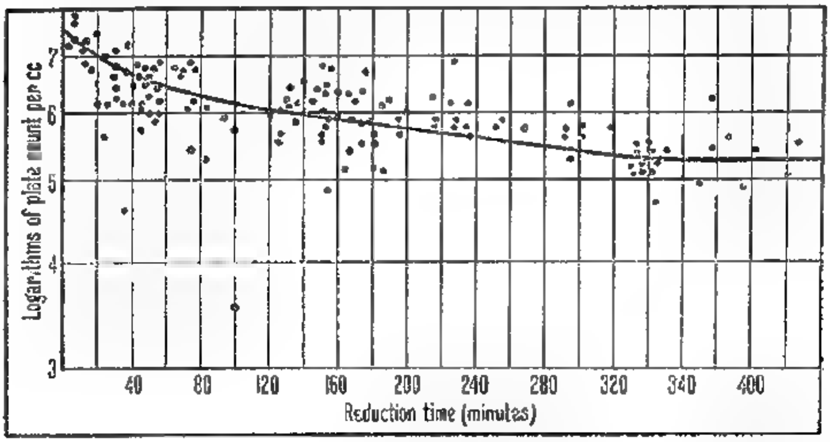

FIG. 1. Relationship between reduction time and standard plate count of each sample of milk examined.

In order to judge the efficiency of the Scandinavian method of interpretation of the reductase test, which gives the empirical equivalent in standard plate count of milk samples examined by the methylene blue reduction method and decolorizing within any of the delimiting times set for the four classes, respectively, the coefficient of correlation, together with the other statistical constants of the reduction time and standard plate count, was computed for each class and for all classes, as shown in Table 6. The table shows that a positive correlation factor was obtained for class I. This was undoubtedly due mostly to sample S–34, which decolorized in 377 minutes but gave the very high plate count of 1,860,000. Several other samples gave seemingly discrepant counts as shown in Table 2 and fig. 1. Classes, II, III, and IV show little, if any, indication of negative correlation. However, a marked negative correlation between decolorization time and standard plate count was obtained when the correlation factor was computed for all the 142 samples comprising the four different classes.

TABLE 6.—*Means, standard deviations, coefficient of variation for, and coefficient of correlation between, the plate counts and reduction times of the 142 samples of milk by the class and for all classes.*[a]

Sample classification, by the class; class (Scandinavian method).	Samples examined.	Statistical constants.			
		Mean.		Standard deviation.	
		Decolorization time.	Plate count.	Decolorization time.	Plate count.
		min.	*Bacteria per cc.*	*min.*	*Bacteria per cc.*
I	21	359.43±4.48	802,621±1[4]	29.76±3.09	365,753±8
II	64	190.44±4.36	1,234,635±1[4]	51.41±3.06	1,319,651±7[4]
III	48	52.08±2.21	3,771,465±3[5]	22.56±1.55	3,189,172±2[5]
IV	9	11.55±1.22	29,815,000±5[6]	5.14± .81	23,983,967±3[5]
For all classes...	142	157 32±5 55	3,765,753±5[5]	116.55±4.99	10,048,006±4[5]

Sample classification, by the class; class (Scandinavian method).	Samples examined.	Statistical constants.		
		Coefficient of variability.		Coefficient of correlation.
		Decolorization time.	Plate count.	
		Per cent.	*Per cent.*	
I	21	8.27±0.66	120.86±14.41	+ 195±0.139
II	64	26.99±1.61	106.87± 6.37	—.100±0.083
III	48	43.32±2.98	87.21± 6 00	—.211±0.093
IV	9	44.54±7.08	80 37 ±12.77	—.491±0.170
For all classes..................	142	74.08±3.17	266.62±11.42	—.339±0.056

[a] A part of the computation used in this table was done by the Division of Statistics, Department of Agriculture and Commerce.

Table 7 shows the coefficient of correlation between reduction time and plate count as obtained by the present and by previous American investigations. The findings of Fay (1930) with 19 samples show that there is little if any indication of correlation. It is important to know, however, that he examined 7 samples belonging to class I, 4 to class II, 8 to class III, and none to class IV. It should also be noted that Fay used various modifications of the reduction test, and dye solution prepared both from tablet and from powder. He also examined each sample in a large series (75 to 100) and some of the samples were examined in two or three series. Fred and Chappelear (1911) examined 199 samples, using dye solution prepared from powder and obtained a coefficient of correlation of — 0.6942 ± 0.03978. This decided negative correlation obtained is undoubtedly due to the fact that in its computation

TABLE 7.—*The coefficient of correlation between plate count and reduction times as obtained by different investigations.*

Number of samples examined, by the class; class.	Investigators.			
	A. C. Fay.	Fred and Chappelear.	Present investigation.	
	Samples.	Samples.	Samples.	Coefficient of correlation.
I	8	108	21	$+0.1950 \pm 0.139$
II	5	47	64	-0.1006 ± 0.083
III	6	33	48	-0.2114 ± 0.093
IV	....	11	9	-0.4915 ± 0.170
Total samples examined......	19	199	142	....
Coefficient of correlation for entire examination.........	-0.82 ± 0.48	$-.6942 \pm 0.08978$	-0.339 ± 0.055	....

they disregarded ten samples "because of their wide variation between consecutive numbers." The results obtained by the present investigation have been discussed above. A direct comparison of the results of the three different investigations is not possible due to some difference in technic.

A cursory search of the different references on this subject revealed that no previous work has been done in correlating the reduction time to the standard plate count for each class of milk as set forth by the Scandinavian scheme of interpretation. Apparently the slight correlation obtained in the present investigation for classes II, III, and IV, as shown in Table 6, was due to the fact that milk contains a very heterogenous and variable bacterial flora. McLeod (1928) and others (Fred, 1912; Hastings, 1919; Hastings, Davenport, and Wright, 1922) believe that although all bacteria are capable of reducing methylene blue, yet they vary considerably in their activities in this respect. Thornton and Hastings (1930) think that the rate of oxygen uptake by bacteria varies sufficiently with different species and under different conditions to introduce an important factor of inaccuracy into the test. It is also possible that some organisms did not grow on agar plates but took part in the reduction of the dye. Some other inherent inaccuracies of the standard plate method as reported by Breed and Stocking (1921), Wright and Thornton (1927), and Schacht and Robertson (1931), such as clumping of bacteria and mis-

takes in counting the colonies, undoubtedly contributed to the poor negative correlation. Furthermore, the high percentage (10.07 per cent) of butter fat of carabao milk, as reported by Gomez (1926), through its creaming may remove a great number of bacteria from the body of the milk and impair the accuracy (Thornton and Hastings, 1930; Thornton, 1933) of the test. Milk, being essentially a mixed culture of various microörganisms of variable species, we have also to take into consideration the complex phenomenon (Holman, 1928) of bacterial "association" which includes "synergism," either antagonistic or beneficent, within its scope. Therefore, dye reduction in milk will be determined not only by the relative number of bacteria present in it but also by the relative number of each organism manifesting either antagonistic or beneficent synergism, since dye reduction is intimately related with the metabolic processes of bacteria. Frazier and Whittier (1931, *b*), studying the influence of the associative growth of two or more species of milk organisms on the oxidation-reduction potential of the milk, found, "that *E. coli*, *E. communior*, and *A. aerogenes*, when grown with *S. lactis*, all exerted a restraining influence on the rapid drops in Eh values usually caused by pure cultures of the latter organism and that the larger the proportion of actively growing colon-aerogenes organisms, the greater is the restraining action." Lactose, which is present in carabao milk to an average amount of 4.93 per cent (Gomez, 1926), must also receive consideration as a factor in the reduction of the dye due to its possible rôle as a hydrogen donator or metabolite in the postulated chemistry of methylene blue reduction. According to Smidt (1906), lactose in the amount of 4.6 per cent has reducing properties. It is also logical to consider fresh milk as a substance of progressively varying hydrogen-ion concentration where the "altering ionic equilibria" at different ranges of pH variously affect the oxidation-reduction system. However, as Hewitt (1933) has pointed out, the effect of the pH on the Eh is complex but not necessarily great; the difference may be within the limits of experimental error when working with biologic material.

Due to the absence of correlation between reduction time and plate count in class I and the existence of little if any indication of correlation in classes II, III, and IV, it seems apparent that the Scandinavian method offers a very inaccurate scheme of interpretation. It will be noted that the writer attempted to correlate the reduction time and the standard plate

count in his attempt to judge the efficiency of the Scandinavian method of interpretation under local conditions. While an exact relationship between the two cannot be expected, yet reduction times will be altogether meaningless unless they can be correlated with the results of well-established methods of sanitary milk control, as the standard plate method, Breed's direct microscopic method, and the like.

TABLE 8.—*The practical efficiency of the Scandinavian method of interpretation of the methylene blue reduction test.*[a]

Classification.	A. Based on reduction time.											
	Total samples.	Checked with standard plate count.										
		Correct samples.		Erratic samples.		Erratic samples with standard plate count corresponding to that of class—						
						I		II		III		IV
			P. ct.		P. ct.		P. ct.		P. ct.		P. ct.	
I	21	20	95	1	5	.....	.....	1	5	0	0	0
II	64	61	79	13	20	11	17	.....	.....	2	3	0
III	48	24	50	24	50	5	10	19	40	.....	.....	0
IV	9	6	66	3	33	0	0	0	0	3	33	.....
For all classes.....	142	101	71	41	28	16	11	20	14	6	3	0

Classification.	B. Based on standard plate counts.												
	Total samples.	Checked with reduction time.											
		Correct samples.		Erratic samples.		Erratic samples with reduction time corresponding to that of class—							
						I		II		III		IV	
			P. ct.		P. ct.		P. ct.		P. ct.		P. ct.		P. ct.
I	36	20	55	16	44	.....	.....	11	30	5	14	0	0
II	71	51	71	20	28	1	2	.....	.....	19	26	0	0
III	29	24	82	5	17	0	0	2	7	.....	.....	3	10
IV	6	6	100	0	0	0	0	0	0	0	0	.....	.....
For all classes	142	101	71	41	28	1	1	13	9	24	16	3	2

[a] Percentage based on the total number of samples placed in the corresponding class.

The poor correlation factor obtained for each class notwithstanding, the methylene blue reduction test cannot be condemned offhand. As has been well said by Fay, "It does not necessarily follow, however, that statistical significance and practical significance are coincident." Table 8 shows the practical evaluation of the efficiency of the Scandinavian method of inter-

pretation. The 142 samples of milk were assorted into their respective classes on two bases: (*a*) On the basis of reduction time and (*b*) on the basis of the standard plate count. The total number of samples examined in each class is given.

(*a*) *Based on reduction time.*—The samples were classified according to reduction time. Then their actual plate counts were checked with that empirically established by the Scandinavian method for the class in which they were grouped. Those that are within the plate-count limits for their respective classes are designated as "correct samples," and those that are not, "erratic samples." The right-hand column gives the class to which the erratic sample in each class should belong on the basis of plate count. Of the 21 samples classified as class I, on the reduction time basis, 20, or 95 per cent, were within the standard plate-count limits set for that class, while one (sample S–34) had a plate count that is within the higher plate-count limits set for class II milk. Similarly, class II gave 51, or 79 per cent, correct samples and 13, or 20 per cent, erratic. Classes III and IV gave only poor percentages of correct samples, 50 per cent and 66 per cent, respectively. It may, therefore, be concluded that while there is no negative correlation between reduction times and plate counts for class I and only slight negative correlation in classes II, III, and IV, it is possible, due to the presence of a marked negative correlation when that factor was based on the entire 142 samples belonging to the four different classes, that a milk sample decolorizing in a given time will, in the majority of cases, give a plate count that will fall within the wide limits set for the class to which it belongs. Table 8 shows this to be true of class I or II milk, but only slightly true in the case of class III or IV. Thus, if we were to examine 300 samples of milk and 100 of such samples decolorized in more than five and one-half hours, the 100 samples would be classified as class I milk in accordance with the Scandinavian scheme of interpretation. The bacteriologic milk standard of the local Board of Food Inspection (1932) for the Philippines has been fixed at 500,000 bacteria per cubic centimeter, which is also the maximum plate-count limit set for class I milk in the Scandinavian method. Of the 100 milk samples in the above example, we can be sure that 95 per cent, or 95 samples, have a lower plate count than 500,000, while 5 per cent, or 5 samples, may have a higher count than this. Thus, no injustice is done to the milk pro-

ducer or distributor. Obviously, the methylene blue reduction test cannot be used for drawing finer distinctions of milk quality as is done in certified milk, but such distinctions are not made in the Philippines. The low practical percentage efficiency for classes III and IV should not impair the usefulness of the Scandinavian scheme of interpretation of this test under our conditions, inasmuch as "bad" and "very bad" milk should find no place in our markets anyway. It is suggested, however, that the Scandinavian method of interpreting this test may be modified to make it better suited to Philippine conditions. The methylene blue reduction test, therefore, answers very well the need of a simple, inexpensive, and sufficiently accurate method for our local milk-control work.

(*b*) *Based on the standard plate count.*—The 142 samples were classified according to their plate counts. Thus, 36 samples were found to have a plate count of less than 500,000 per cc and were classified as class I. There were 71 samples that had a plate count of between 500,000 and 4,000,000 and were classified as class II. Classes III and IV were similarly treated. The reduction time of each sample was then checked with the reduction-time limits set for the class to which it belongs. If they check with each other, the sample is designated a correct sample, and if not, erratic sample. Obviously the erratic samples on the reduction-time basis and on the standard plate-count basis are the same and are so indicated in Tables 2, 3, 4, and 5. It will be noted that of the total of 41 erratic samples only three (S–34, S–10, and S–46) gave a higher plate count than the maximum arbitrary limit set for the class to which they belong, while the rest gave a count lower than the minimum. The absence of excessive leucocytes and long-chain streptococci, on microscopic examination of those samples, however, showed that they were not cases of abnormal milk. Evidently the latter group contained a predominant bacterial flora with pronounced reducing power. This should not upset the efficiency of the reduction test since Ellenberger and his associates (1927) have shown that the methylene blue reduction time correlates much more closely with the keeping time of milk than does the agar-plate count.

SUMMARY

1. The efficiency and interpretation of the methylene blue reduction test was studied under local conditions.

2. Results on 142 samples of milk examined confirmed previous findings that this test is characterized by a low degree of variability between replicate tubes.

3. The meager correlation obtaining between reduction time and plate count when each class is taken individually indicates, not defect in the methylene blue reduction test, but rather a necessity for modifying the Scandinavian method of grouping to suit local conditions.

4. The marked negative correlation obtaining for all the 142 milk samples taken together, without regard to classes, points, on the other hand, to the high degree of efficiency and dependability of the methylene blue reduction test. Owing to its simplicity, it would be more suitable than the standard plate method in the Philippines. It should, therefore, be seriously considered for adoption as the standard procedure in our local milk test.

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ILLUSTRATION

TEXT FIG. 1. Chart showing the relationship between reduction time and standard plate count of each sample of milk examined.

MINERAL CONSTITUENTS IN FRESH AND CANNED MILK

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Milk is the most satisfactory single article of food, especially for infants, because it contains proteins of good quality, oil-soluble vitamins, and also important mineral constituents, such as calcium, phosphorus, iron, copper, and manganese. Milk has only a small quantity of iron, but is high in calcium. According to Sherman(9) the iron of milk is readily absorbed and assimilated.

The dairy industry in the Philippine Islands is still undeveloped and at present pasteurized milk is rather expensive. Both the wealthy and poor people generally use canned milk for feeding infants.

Daniels and Laughlin(4) reported that the process of pasteurization renders the calcium salts in milk somewhat insoluble. In the pasteurization apparatus a deposit (milk stone) is usually formed. During the process of preparing sterilized natural milk and evaporated and sweetened condensed milk slow heating may remove very appreciable amounts of calcium. The storing and aging of milk in a hot tropical country also affects the composition of the milk.

Some analyses of canned milk sold in the Philippines and also native milk, both human and carabao, have been made.(2) The results give data on the common milk constituents, such as fat and ash, but do not give any definite information concerning the amounts of calcium, iron, and phosphorus contained in the milk.

In this investigation a number of samples of milk were analyzed particularly for the calcium, iron, and phosphorus contents in addition to the common milk constituents. We purchased the most popular brands of milk sold in the grocery stores in Manila. Various kinds of milk, such as natural sterilized, evaporated, sweetened condensed, and powdered milk, were investigated. In addition to canned milk we also analyzed reconstituted cow's milk and fresh milk from carabaos, goats,

and cows kept at the Alabang experiment station of the Bureau of Animal Industry. Altogether forty-five samples of milk were analyzed.

The analyses of the milk for fat, protein, and the other common constituents were made according to the methods of the Association of Official Agricultural Chemists.(8) The results are recorded in Table 1. The calcium, phosphorus, and

TABLE 1.—*Analyses of various kinds of milk.*

Kind of milk.	Water.	Fat.	Ash.	Protein (Nx6.38).	Lactose (by difference).	Sucrose.
Natural sterilized milk:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Bear	87.05	3.52	0.72	3.32	5.39	----------
Brunn	87.28	3.52	0.76	3.31	5.13	----------
Hollandia	68 20	3 52	0.75	0.16	4.37	----------
Milkmaid	87.95	3.52	0.73	3.24	4.56	----------
Phoenix	28.00	3.87	0 66	3.39	4.08	----------
Evaporated milk:						
All Pure	70.83	7.90	1.46	8.53	11.29	----------
All Pure (goat's milk)	73.00	9.89	1.34	5.99	9.78	----------
Alpine	70.90	7.92	1.63	9.21	10.34	----------
Armour	69.10	8.10	1.33	9.08	12 39	----------
Carnation	70.11	7.88	1.51	7.72	12.78	----------
Darigold	74 08	7.47	1.08	6 59	9 78	----------
Libby	68 05	7.92	1.54	8.70	13.79	----------
Meiji	72.58	7.95	1.65	7.95	9.87	----------
Milkmaid	69.37	8.10	1.64	8.66	12.25	----------
Pet	69 91	7.87	1.87	6.70	13.65	----------
Powdered milk:						
Dryco	3.14	12.50	7.43	32.09	44.84	----------
Horlick	3.28	16.72	3.84	14.01	63.16	----------
Klim	1.58	28.22	5.48	24.56	40.16	----------
Lactogen	1.68	24.44	5 13	24.77	43.98	----------
Mellco	1.40	28.04	5.80	26.87	37.89	----------
Nestogen	2.78	21.62	4.95	20.59	50.06	----------
Fresh goat's milk from Alabang:						
Anglo Nubian No. 1342	86.44	3.07	0 81	3.07	6.61	----------
Grade Nubian No. 1227	88.70	3.84	0.66	3.04	3.76	----------
Grade Nubian No. 1312	87.40	3.87	0.64	3.36	4.73	----------
Grade Nubian No. 1350	86.27	4.67	0.76	3.34	4.96	----------
Toggenberg breed No. 1025	87.92	3.24	0.83	3.19	4.82	----------
Toggenberg breed No. 1027	87.64	3.89	0.78	3.86	4.23	----------
Miscellaneous samples (fresh milk):						
Red Scindi cow No. 6 second lactation	89 15	3.32	0.82	3.00	3 71	----------
Red Scindi cow, 6 years, third lactation	87.20	3.26	0.84	3.30	5.38	----------
Cow No. 1281. Half-breed Ayrshire and Nelson	87.07	4.80	0.86	3.57	3.72	----------

TABLE 1.—*Analyses of various kinds of milk*—Continued.

Kind of milk.	Water.	Fat.	Ash.	Protein (Nx6.38).	Lactose (by difference).	Sucrose.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Miscellaneous samples (fresh milk)—Continued.						
Cow No. 2291. One-fourth Ayrshire and Nelson, second lactation	86 98	3.89	0.82	3.13	5.18	----------
Carabao milk (local dairy)	79.63	10.05	0.64	5.38	4.30	----------
Magnolia reconstituted milk. Prepared from butter and powdered skimmed milk	87.13	3.61	0.78	3.14	5.34	----------
Sweetened condensed milk:						
Brunn	20.08	10.08	2.06	7.04	14.17	46.57
Carnation	20.50	8.02	1.92	8.62	12.65	48.39
Geraco	22 39	8.64	1.69	8.12	13.70	45.46
Hollandia	22 88	8 02	1 50	8.42	14.43	44.75
Libby	23.23	8.92	1.79	7.04	14.68	44.86
Lifeguard	23.53	8.64	1.55	8.05	12.24	45.94
Merry	20.31	9.36	1.92	8.07	11.95	48.39
Milkmaid	20.12	9.86	1.93	8.75	13.69	46.25
Morinaga	20 86	10 08	1.91	8.02	14.77	44.36
My Boy	24.17	8.02	1.69	8 12	11.43	46.57
Swan Danish	20.85	8.64	1.88	9.22	16.13	44.28
Train	24.26	9.36	1.72	7.79	13.46	43.41

iron contents of the milks are given in Table 2. The calcium and phosphorus were determined by the official methods applicable to plant materials other than seeds.(8) Analysis for iron was made according to Stugart's method.(10)

RESULTS

The results for evaporated whole milk, powdered whole milk, and sweetened condensed milk agree, in general, with the data given by the associates of Rogers(3) for these products.

Fresh cow's milk gave a higher percentage of ash (Table 1) and calcium (Table 2) than the natural sterilized milk.

Milk from carabaos had the lowest ash content (0.64 per cent) but the ash had the highest amount of calcium (27.99 per cent). Carabao milk also had more fat and protein than the other natural fresh milks (Table 1).

The Toggenberg breed of goats gave milk with a higher lime content than any other breed of goats.

Klim and Molico (whole powdered milks) gave the highest percentage of fat.

TABLE 7.—*Mineral contents of various kinds of milk.*

Kind of milk.	CaO			P_2O_5			Fe_2O_3		
	On wet basis.	On dry basis.	In ash.	On wet basis.	On dry basis.	In ash.	On wet basis.	On dry basis.	In ash.
Natural sterilized milk:									
Bear	0.17	1.36	24.52	0.24	1.85	33.34	0.00035	0.00271	0.0500
Brunn	0.18	1.46	24 44	0.20	1.60	26.79	0.00031	0.00243	0.0443
Hollandia	0.18	1.51	23 82	0.21	1.78	28.06	0.00035	0.00300	0.0486
Milkmaid	0.17	1.44	23.90	0.23	1.91	31.65	0.00034	0.00271	0.0473
Phoenix	0.15	1.31	23.89	0.23	1.92	34.98	0.00032	0.00273	0.0507
Evaporated milk:									
All Pure	0.32	1.12	22.58	0.44	1.50	30.29	0.00084	0.00282	0.0587
All Pure (goat's milk)	0.32	1.19	23.97	0.47	1.76	35.64	0.00067	0.00248	0.0407
Alpine	0.39	1.36	24.16	0.53	1.83	29.94	0 00070	0.00240	0.0428
Armour	0.35	1 12	26.18	0.46	1.49	34 65	0.00070	0.00230	0.0533
Carnation	0.38	1 26	25.06	0.45	1.52	30.19	0.00075	0.00253	0.0507
Darigold	0.28	0.99	25.31	0.38	1.46	35.03	0.00068	0.00264	0.0643
Libby	0.27	1.17	24.38	0.45	1.43	29.69	0.00074	0.00233	0.0486
Meiji	0.37	1.34	22.38	0.49	1.79	29.80	0.00074	0.00270	0.0457
Milkmaid	0.40	1.31	25.03	0.45	1.48	28.43	0.00073	0.00237	0.0457
Pet	0.46	1.54	24.88	0.56	1.86	29 97	0.00080	0.00265	0.0428
Powdered milk:									
Dryco	1.79	1 86	24.18	2.21	2.28	29.76	0.00373	0.00384	0.0503
Horlick	1.96	1.00	25.21	1.14	1.18	29.80	0.00385	0.00418	0.1005
Klim	1.28	1.30	23.44	1.75	1.78	32.04	0.00600	0.00609	0.1095
Lactogen	1.27	1.29	24.75	1.64	1.65	32.04	0.00553	0.00561	0.1079
Molico	1.46	1.48	25.17	1.72	1.77	29.75	0.00619	0.00633	0.1059
Nestogen	1.24	1.27	26.03	1 53	1.58	31.02	0.00339	0.00348	0.0585

Fresh goat's milk from Alabang:									
Anglo Nubian No. 1342	0.19	1.45	24.40	0.24	1.79	30.01	0.00037	0.00271	0.0461
Grade Nubian No. 1227	0.15	1.37	23.55	0.21	1.87	32.02	0.00035	0.00314	0.0544
Grade Nubian No. 1312	0.16	1.27	25.00	0.20	1.57	31.01	0.00030	0.00208	0.0473
Grade Nubian No. 1350	0.19	1.37	24.72	0.23	1.66	29.75	0.00031	0.00228	0.0427
Toggenberg breed No. 1025	0.20	1.74	24.24	0.24	2.04	29.73	0.00038	0.00320	0.0476
Toggenberg breed No. 1027	0.19	1.54	24.49	0.23	1.86	29.52	0.00032	0.00257	0.0421
Miscellaneous samples (fresh milk):									
Red Scindi cow No. 5	0.19	1.78	23.68	0.24	2.24	29.72	0.00037	0.00341	0.0470
Red Scindi cow, 6 years, third lactation	0.20	1.56	23.77	0.26	1.94	29.59	0.00031	0.00244	0.0390
Cow No. 1281, half breed Ayrshire and Nelson	0.20	1.59	24.24	0.25	1.94	29.56	0.00030	0.00231	0.0358
Cow No. 2291, 5 years, three-fourths Ayrshire one fourth Nelson, second lactation	0.20	1.52	24.19	0.24	1.87	29.69	0.00038	0.00295	0.0487
Carabao milk	0.18	0.88	27.99	0.21	1.04	32.27	0.00031	0.00300	0.0490
Magnolia reconstituted milk	0.19	1.47	24.19	0.25	1.93	31 87	0.00034	0.00328	0.0438
Sweetened condensed milk:									
Brunn	0.49	0.62	24.02	0.64	0.80	31.13	0.00110	0.00137	0.0534
Carnation	0.48	0.60	25 04	0.60	0 76	31.28	0.00107	0.00135	0.0564
Garsco	0.41	0.53	24 40	0.54	0.72	33.05	0.00127	0.00162	0.0753
Hollandia	0.35	0.45	23.45	0.47	0.66	31.23	0.00095	0.00124	0.0644
Libby	0.41	0.54	23.60	0.54	0.71	30.79	0.00107	0.00140	0.0612
Lifeguard	0.39	0.51	25.07	0.48	0 63	31.27	0.00088	0.00115	0.0773
Merry	0.45	0.57	23 82	0.61	0.77	32.05	0.00104	0.00130	0 0544
Milkmaid	0.45	0.57	23.70	0.57	0 71	29.64	0.00095	0.00120	0.0504
Morinaga	0.45	0 57	23.78	0.56	0 71	29.63	0.00100	0.00127	0.0529
My Boy	0.40	0.53	24.07	0.53	0.70	31.43	0.00095	0.00125	0.0571
Swan Danish	0.44	0.56	23.77	0.57	0.72	30.34	0.00098	0.00124	0.0524
Train	0.45	0.57	23.78	0.56	0.71	29.63	0.00100	0.00127	0.0529

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SUMMARY

In this investigation forty-five samples of milk were analyzed particularly for the calcium, iron, and phosphorus contents. The common milk constituents, such as fat and ash, were also determined.

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THE BREEDING HABITS OF ANOPHELES LITORALIS AND A. INDEFINITUS IN SALT-WATER PONDS [1]

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SEVEN PLATES AND TWO TEXT FIGURES

Miscellaneous collections of *Anopheles* larvæ in salt-water and brackish-water ponds near Manila had been made during the dry season in 1929 and again in 1931, and brief notes on the occurrence of *A. litoralis* King and *A. indefinitus* Ludlow (*A. subpictus* var. *indefinitus*) in these ponds were given in a previous article.[2] The observations had indicated that the optimum salt concentration was somewhat different for each of the two species. During the year beginning July, 1931, periodic collections were made in the same ponds in order to obtain information on the relative species variation in the rainy and dry seasons, and the records are summarized in the present paper.

Near the municipality of Las Piñas, about 14 kilometers south of the Government center in Manila, is an area where salt is manufactured by the evaporation of sea water. The salt beds (Plate 2), which are paved or tiled and from which the salt is collected after evaporation has taken place, are connected with a series of concentration ponds where the preliminary evaporation occurs. The pond farthest from the salt beds is connected by a ditch with one of the numerous esteros, or tidal canals. During the period of salt manufacture the inflow of water at one end and the collection of salt at the other

[1] The studies on which this paper is based were conducted with the support and under the auspices of the International Health Division of the Rockefeller Foundation, in coöperation with the Bureau of Science of the Philippine Government.

[2] King, W. V., Philip. Journ. Sci. 47 (1932) 305–342, illus.

are more or less continuous, so that the salt concentration in the different ponds is progressively higher. The plot selected for observation consisted of a series of five ponds separated from one another by low dikes (Plate 1 and text fig. 1), the upper one of which was designated C–4, the next C–3, etc., the salt bed being C–0. Regular collections were made only in C–3

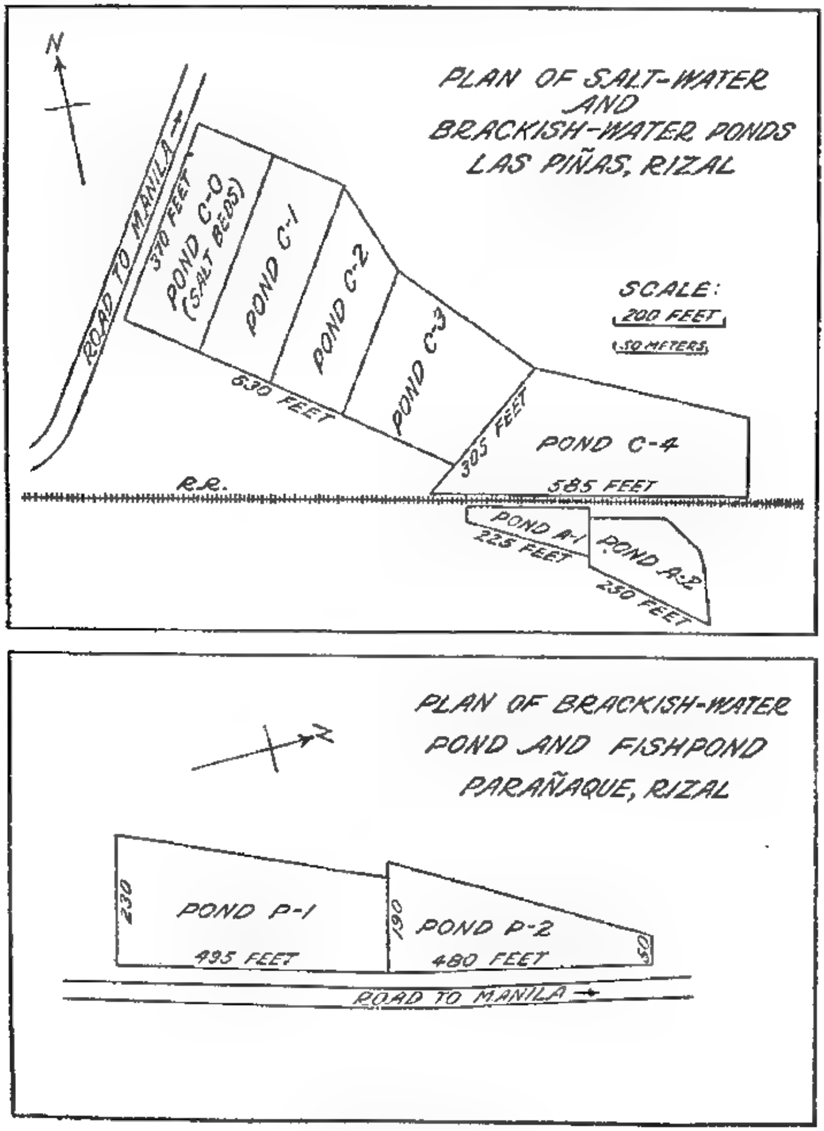

FIG. 1. A sketch of the ponds where *Anopheles*-breeding studies were made, showing their approximate size and location.

and C–4, but occasional collections were also made in the other ponds.

Across a railroad embankment from the upper end of the concentration ponds were two smaller, unused pools, which had no direct connection with sea water and usually contained only brackish water. These are referred to as ponds A–1 and A–2 (Plates 4 and 5). The second of these (A–2) was separated from an adjoining fishpond only by a small dike, and it probably received an overflow of salt water occasionally, as its salt content was higher than that of A–1 most of the time.

Two other ponds near the municipality of Parañaque and 4 or 5 kilometers nearer Manila were also selected for the collections. One of these (pond P–2, Plate 6) is a fishpond that is supplied with sea water as required to maintain the proper level; the other (P–1, Plate 7) is an abandoned fishpond and, although separated from P–2 merely by a dike, contained only slightly brackish water except when its volume had been greatly reduced by evaporation.

The six ponds (text fig. 1) in which regular collections were made consisted, therefore, of three "salt-water ponds" (C–4, C–3, and P–2) and three "brackish-water ponds" (A–1, A–2, and P–1). The descriptive terms are only approximate, however, since the water in all the ponds becomes much diluted during the rainy season and highly concentrated during the dry season. The dividing line between "brackish" and "salt" is not definite either, but for our purposes brackish water is considered as containing up to 2 per cent of salt and salt water above 3 per cent, between 2 and 3 per cent being intermediate.

METHODS OF DETERMINING THE SALT CONTENT

For the purpose of this study it was considered unnecessary to determine the salt content with great accuracy (as by titration for chlorine or other chemical method), and the salt percentages were calculated simply from hydrometer readings. These were made with two instruments on nearly all samples, one being used as a check against the other. One was a small specific-gravity spindle graduated from 1.000 to 1.060 and calibrated at 15° C. (59° F.), and the other was a salt hydrometer graduated from 0 to 100 per cent of saturation and calibrated at 60° F. Since the temperature of the pond water varied from about 26° to 31° C. (78.8° to 87.7° F.), the readings were corrected approximately to these temperatures. For

the specific-gravity readings a table and graph giving the percentages of salt with water temperatures of 27° and 30° C. (80.6° and 86° F.) were drawn up from Olsen's salt table by multiplying the specific-gravity readings by factors of 1.00259 and 1.00346, respectively, and correcting to the nearest of these two temperatures. For the salt hydrometer a graph was drawn for the corrected readings at 29° C. (84.2° F.).[3] The salt hydrometer was expected to be less accurate than the specific-gravity spindle, since it covered a wider range of salt concentration, but the readings proved to be fairly close, with variations of only 0.1 to 0.3 per cent in the majority of cases. It might be mentioned, however, that on comparing three specific-gravity spindles, all calibrated at the same temperature, considerable variation was shown, averaging about four points (0.004) and corresponding to about 0.55 per cent of salt difference between the highest and the lowest. One of these was a urinometer and the other a standard-size specific-gravity hydrometer. The intermediate one of the three gave the nearest to correct readings when tested with known solutions and is the one from which the percentages used in the present paper were taken.

Check readings with this spindle on known solutions, in which the sodium chloride had been thoroughly dried before weighing, were as follows:

Salt (NaCl) in 100 cc of solution ...g..	1.00	2.00	3.00
Specific gravity readings at 30.5° C. (86.9° F.)	1.0045	1.0115	1.0180
Calculated percentage of salt	1.09	2.07	2.97

IDENTIFICATION OF MATERIAL

Most of the identifications were made of fourth-instar larvæ, and the characters that were mainly depended upon for the separation of the two species considered in this paper were as follows:

Anopheles litoralis.—First palmate hair undeveloped, hairlike, or, if leaflets slightly broadened, without a differentiated filament; pecten with all the teeth of nearly equal length.

Anopheles indefinitus.—First palmate hair, although smaller than the succeeding ones, with developed leaflets and apical filaments; pecten with some of the teeth about twice the length of the others.

[3] The table and graphs were prepared by Mr. José C. Espinosa, of the Bureau of Science, to whom the authors wish to express their indebtedness.

These characteristics are not very pronounced and, at the beginning of the study, a considerable number of the larvæ were reared through to the adult stage in order to have a check on the specificity of the characters and on the accuracy of identification. The total numbers of specimens identified in both the larval and adult stages, those collected as pupæ and identified in the adult stage only, and those determined only as larvæ are shown in Table 1. The data also indicate that the emergence of females of these two species is only slightly in excess of that of males.

TABLE 1.—*Total numbers of specimens of Anopheles litoralis and A. indefinitus collected in the ponds under observation.*

Identifications.	*A. litoralis.*			*A. indefinitus.*		
	Total.	Males.	Females.	Total.	Males.	Females.
Both as larvæ and adults	587	287	300	1,672	778	894
As adults only	550	263	287	535	246	289
As larvæ only	3,895			753		
Total	5,032	550	587	2,960	1,024	1,183

Although culicine larvæ were frequently abundant in the ponds, the only other anophelines encountered in these breeding places during the study were four specimens of *Anopheles philippinensis* Ludlow collected by F. E. Baisas from pond P–1, February 5, at a time when the pond was filled with fresh water.

RAINFALL

The normal annual rainfall for Manila, according to the records of the Manila Central Observatory, is 2,046.8 mm (80.6 inches), more than two-thirds of which (1,455 mm) occurs during the four months from June to September. The five months from December to April comprise a distinctly dry season, with an average monthly rainfall of only 29 mm (1.14 inches).

As shown in Table 2, the greatest departures from normal occurred during July and August, at the beginning of the period covered by the study. Less than half of the normal rainfall occurred in July; so the water level of the ponds was not much raised during this month. The total of 1,466 mm (57.7 inches) in August, however, was more than three times the normal, and exceedingly heavy downpours on the 11th, 12th, and 13th,

when a total of 721 mm (28 inches) was recorded, completely flooded all the collecting areas and eliminated practically all mosquito breeding for the time being. Although the excessive amount of water at this time was far from normal, the extreme variation undoubtedly provided more interesting data than might otherwise have been obtained. In contrast, the four months from January to April were almost rainless and made possible observations at the opposite extreme.

TABLE 2.—*Monthly rainfall July, 1931, to June, 1932, inclusive, and normal rainfall for Manila.*

Month.	1931–1932		Normal.	
	mm.	in.	mm.	in.
July	180.4	7.10	418.4	16.47
August	1,465.9	57.71	426.6	16.79
September	329.6	12.98	355.3	13.99
October	170.9	6.73	187.9	7.40
November	249.1	9.81	138.1	6.44
December	95.9	3.77	60.9	2.40
January	0.3	0.01	24.4	0.96
February	0.0	0.00	11.2	0.44
March	7.9	0.31	17.7	0.70
April	0.0	0.00	31.4	1.24
May	164.7	6.48	120.0	4.72
June	315.8	12.43	255.0	10.04
Total	2,980.6	117.33	2,046.8	80.59

BREEDING CONDITIONS AND ALGAL GROWTHS IN THE PONDS

Breeding of *Anopheles* larvæ in these ponds is practically always associated with growths of aquatic vegetation, usually algæ. Therefore, notes were kept on the principal species and the amounts present in the ponds at various times. The commonest forms encountered during the survey were as follows:[4]

Chaetomorpha sp., a coarse filamentous green alga, which forms large floating mats in the fishponds and the salt-concentration ponds, is normally found in water of a fairly high salt content and usually indicates the presence of *A. litoralis* larvæ. In the ponds where it was well established prior to the rainy season, it was found to develop after the salt water had been much diluted, and under these conditions contained *A. indefinitus* larvæ. However, it was seldom found in the

[4] The authors are indebted to Dr. E. Quisumbing, of the Bureau of Science, and to Prof. N. L. Gardner, of the University of California, for identifications of the algæ.

brackish-water ponds even after the salt content had increased as a result of evaporation. In the other ponds this alga, with *Lyngbya majuscula*, was the predominant growth during the dry season (Plates 3 and 6).

Lyngbya majuscula, a filamentous blue-green alga with a much finer strand than *Chaetomorpha*, is more frequently found in salt-water than in brackish-water ponds, and its mats may or may not be mixed with those of *Chaetomorpha*. The dark brown or bluish appearance of the mats distinguishes them from the light yellowish green of *Chaetomorpha* mats. Large mats of a nearly pure growth of this species occurred in pond A–2 (Plate 5) from February to July, at salt percentages ranging from 1.6 to 9.2. In the fishpond (P–2) the species was abundant from April to July.

Lyngbya aestuarii, similar in general to the preceding species, but probably preferring water of a lower or intermediate salt concentration, was recorded most frequently in ponds C–3 and C–4 from September to February, at salt concentrations of from 1 to 4 per cent and appeared in large mats at concentrations of from 1.0 to 1.6 per cent. It disappeared (or was observed only in a decayed condition) after February 19 and was not observed during the remainder of the dry season.

None of these three species occurred to any extent in the two more strictly brackish-water ponds, A–1 and P–1, and, in fact, were recorded in these only three or four times, in small quantities.

Enteromorpha tubulosa, a large, tubular alga of irregular occurrence, both as to type of pond and amount of salt, was recorded as abundant in water ranging from 0 to more than 4 per cent salt, and as moderately abundant in water of salt content up to 6 per cent. It was noted most frequently in ponds A–1 and P–2, and in the ditch along the side of C–1 and C–2. The large size of the filament and the loosely formed growths, which are never extensive, make it a much less favorable source of larval food or protection than the other forms. In certain collections, however, it was the only or principal species recorded at times when larvæ were numerous, these consisting sometimes of *A. litoralis* and sometimes of *indefinitus*.

Hydrocharitaceæ. A plant, similar in general appearance to *Chara* but thought by Doctor Quisumbing to belong to the frogbit family, grew luxuriantly in the three brackish-water ponds and produced favorable mosquito-breeding conditions, usually containing *A. indefinitus* but occasionally *litoralis* also.

Pond A–1 and the much larger pond P–1 were almost completely filled with this *Chara*-like plant during a large part of the year. It disappeared during the dry season but quickly became reëstablished with the beginning of the rains, showing up in the bottom of A–1 while the salt content was still 2.5 per cent. In pond A–2 it was noted as fairly abundant from January 8 to March 4. It was also found in the concentration ponds C–4 and C–2 from October to November (during the rainy season), where it developed while the water contained less than 1.25 per cent of salt. It was recorded as abundant in C–4 October 14 and in C–3 each of the three collecting dates from October 14 to November 3. In the fishpond (P–2) it was noted in small amounts from November 3 to January 22, when the salt content ranged from 1.0 to 2.7 per cent, which appeared to be nearly the limit of tolerance.

Certain other algæ, such as *Spirogyra, Xenococcus, Lyngbya confervoides*, and *Pithophora* sp., were identified by Professor Gardner from our material, but they were seldom abundant enough to be much of a factor in mosquito breeding. Of the higher plants, duckweed (*Lemna* sp.) and a species of salt grass (*Paspalum vaginatum*) were noted on occasion, and during January the duckweed formed a heavy growth on the surface of pond A–1.

As a result of the excessive flooding in August, practically all the floating algæ disappeared, having either been sunk or washed away, and the *Chara*-like plant, which was rooted in the bottom mud, was covered so deeply with water that the tops failed to reach the surface. August 17 only two larvæ could be found in the ponds after several hours' search. By September 3 the water level had lowered and the tops of the *Chara*-like plant reached the surface in ponds A–1 and P–1, where *Anopheles* breeding had been resumed. A small amount of *Lyngbya aestuarii* was noted in ponds C–3 and C–4 on this date, and larvæ were found in this alga September 14.

Even after the return of more normal water conditions the plant growths were subject to considerable, sometimes sudden, variations both as to species and abundance, due to changes in the salt content of the water, to hand removal in some cases, and to other, undetermined, causes. Certain of the abrupt changes in larval abundance in individual ponds and on consecutive collection dates were attributable to such fluctuations in the algal growths.

As elsewhere, the algal and other plant growths undoubtedly serve both as larval food and as protection against fish and other predators. Only once were larvæ found unassociated with such growths, and this was May 20 in small pools recently formed in pond P–1, which had previously been completely dry. In the absence of both fish and algæ, larvæ of *A. litoralis* were found floating free on the surface, much like those of *A. vagus* in similar open pools of fresh water.

VARIATIONS IN SALT PERCENTAGES

The maximum and minimum salt percentages on each collecting date are given in Table 3 and text fig. 2. The percentages for each of the ponds are included in Table 4.

The first collection of the series was made after the rainy season had begun, with the ponds already beginning to show dilution. Immediately after the heavy August rains hardly a trace of salt could be noted in most of the breeding places, and the maximum reading August 17 was 0.7 per cent. By the next collecting date (September 3) ponds P–2 and C–4 had recovered somewhat, but during the remainder of 1931 the rainfall was sufficient to maintain all the ponds in a diluted condition, with a maximum showing of 1.7 per cent salt. The first pond to go above 2 per cent, probably as a result of the letting in of sea water, was the fishpond P–2, in which a reading of 2.3 per cent was obtained January 8. The same date pond A–1 began to show an appreciable amount of salt again,[5] after a lapse of two months, probably indicating that evaporation had begun to exceed the precipitation. February 5 the salt pond C–4 showed 3.5 per cent salt, and February 19 the brackish pond P–1 showed the presence of salt for the first time since July.

In March the concentration ponds and salt beds were cleaned preparatory to salt manufacture, and until June 22 the salt content in these remained above 4 per cent, mostly from 5 to 7 per cent. The brackish pond A–2 rose to 1.3 per cent salt February 5 and to 3.0 per cent March 4, taking the status of a salt pond for the remainder of the dry season. Pond A–1 reached 2.3 per cent salt April 15 and 4.2 per cent the 29th. Pond P–1 gave a reading of 1.4 per cent April 1 and 2.5 per cent April 15, but was entirely dry the 29th. After light rains

[5] See footnote *a*, Table 3.

TABLE 3.—*Collections of Anopheles larvæ and salt content of water in the breeding places.*

Date.	Collections from selected stations.						Additional collections.				Totals.	
	Collections.	*A. litoralis.*	*A. indefinitus.*	Per collection.		Salt content.[a]	Collections.	*A. litoralis.*	*A. indefinitus.*	Salt content.[a]	*A. litoralis.*	*A. indefinitus.*
				A. litoralis.	*A. indefinitus.*							
1931						*Per cent.*				*Per cent.*		
July 27	4	198	15	49.5	3.7	1.6–3.1	1	3	0	3.1	201	15
August 17	4	1	1	0.2	0.2	0.0–0.7					1	1
September 3	4	60	68	15.0	17.0	0.0–1.1					60	68
September 14	5	60	127	12.0	25.4	0.0–1.3					60	127
September 24	6	72	218	12.0	36.3	0.0–1.3	1	4	3	1.1	76	221
October 4	6	44	478	7.3	79.7	0.0–1.0					44	478
October 14	6	47	294	7.8	49.0	0.0–1.1					47	294
October 24	6	29	239	4.8	39.8	0.0–1.0					29	239
November 3	6	17	128	2.8	21.3	0.0–1.1					17	128
November 18	6	2	106	0.3	17.7	0.0–1.3					2	106
December 16	5	14	196	2.8	39.2	0.0–1.7					14	196

1932												
January 8	6	7	119	1.4	23.8	0.0-2.8					7	119
January 22	5	7	154	1.4	30.8	0.0-2.8					7	154
February 5	5	110	178	22.0	35.6	0.0-3.5					110	178
February 19	5	170	183	34.0	36.6	0.3-4.2					170	183
March 4	6	151	97	25.2	16.2	0.6-6.0	3	51	0	2.7-6.7	202	97
March 18	6	330	113	55.0	18.8	0.9-5.5	3	142	0	2.8-7.3	472	113
April 1	6	586	219	97.7	36.5	1.4-6.7	4	353	0	4.2-8.8	939	219
April 15	6	331	2	55.2	0.3	2.3-6.7	4	135	0	3.7-8.8	466	2
April 29	5	198	0	39.6	0.0	4.2-6.6	4	386	0	4.6-6.0	584	0
May 20	6	340	0	56.7	0.0	3.5-9.2	3	184	0	4.6-4.8	524	0
June 22	6	331	0	55.2	0.0	1.6-4.2	2	80	0	3.0	411	0
July 15	6	565	22	94.2	3.7	1.3-3.2	2	24	0	2.8	589	22
Total or average	125	3,670	2,957	29.4	23.7		27	1,362	8		5,032	2,960

[a] Specific gravity of 1,000 or less and hydrometer readings of 0 were usually recorded as 0 per cent salt without adjustment for temperature. A certain amount of salt was undoubtedly present in solution at all times.

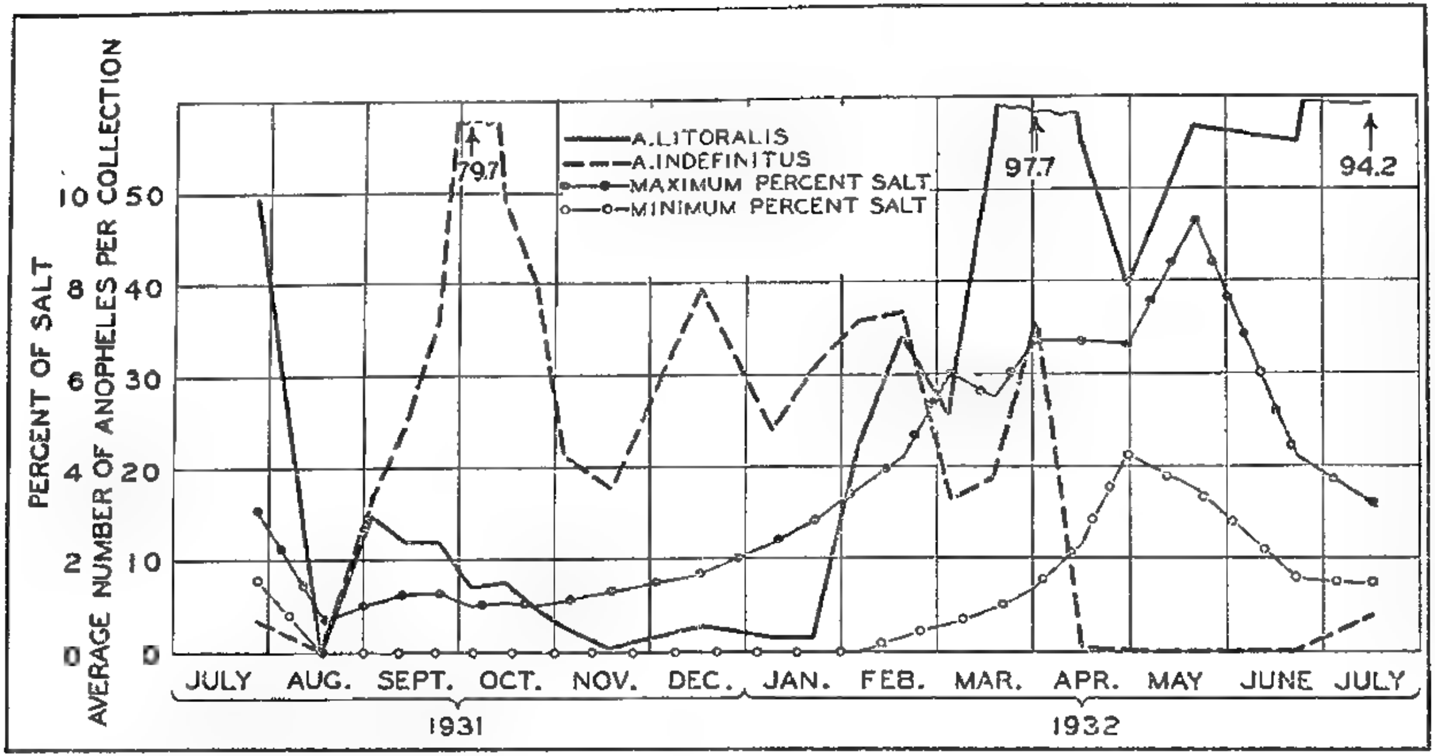

FIG. 2. The salt content and the seasonal abundance of larvæ of *A. litoralis* and *A. indefinitus* in six ponds under observation from July, 1931, to July, 1932. The circles on the lines representing maximum and minimum percentages of salt do not coincide with the dates of observation, which were the same as those for the larval collections.

in May several pools were formed and the water, after standing on the salt-impregnated soil, showed from 3.5 to 4.6 per cent salt (P–1 and P–1a).

The period covered by the study extended into the beginning of the second rainy season and, rather curiously, in the five ponds from which collections were made both the first and last dates of the series, the salt percentages had returned July 15, 1932, nearly to the points at which they had begun July 27, 1931.

TABLE 4.—*Salt content and collections of Anopheles larvæ in individual ponds.*

Date.	Pond A–1.			Pond A 2.			Pond P 1.		
	Salt content.	Larvæ.		Salt content.	Larvæ.		Salt content.	Larvæ.	
		A. litoralis.	*A. indefinitus.*		*A. litoralis.*	*A. indefinitus.*		*A. litoralis.*	*A. indefinitus*
1931	*Per cent.*			*Per cent.*			*Per cent.*		
July 27	--------	--------	--------	2.4	43	0	1.6	83	15
Aug. 17	0.7	0	0	([a])	--------	--------	0.0	1	1
Sept. 3	0.8	26	42	([a])	--------	--------	0.0	34	26
Sept. 14	0.9	3	46	1.2	0	0	0.0	7	61
Sept. 24	0.5	0	59	0.9	3	0	0.0	0	94
Oct. 4	0.7	1	175	1.0	0	24	0.0	0	64
Oct. 14	0.7	0	117	1.0	2	14	0.0	0	91
Oct. 24	0.6	0	41	0.9	0	12	0.0	0	78
Nov. 3	0.6	0	17	1.0	4	5	0.0	0	17
Nov. 18	0.0	0	19	0.6	0	6	0.0	0	17
Dec. 16	0.0	0	56	0.7	1	19	0.0	0	64
1932									
Jan. 8	0.5	0	10	0.8	0	12	0.0	0	39
Jan. 22	0.6	0	18	0.9	0	12	0.0	0	41
Feb. 5	0.4	0	14	1.3	0	74	0.0	0	[b] 88
Feb. 19	0.6	0	24	1.6	20	41	0.3	0	116
Mar. 4	0.7	0	67	3.0	86	9	0.6	0	21
Mar. 18	0.9	117	43	4.2	107	0	0.9	0	70
Apr. 1	1.4	91	109	6.7	166	0	1.4	0	110
Apr. 15	2.3	162	1	6.7	47	0	2.5	0	1
Apr. 29	4.2	128	0	6.6	0	0	([c])	([c])	([c])
May 20	5.4	136	0	9.2	0	0	3.5	104	0
June 22	2.6	84	0	4.2	76	0	1.6	44	0
July 15	1.5	124	16	3.2	148	0	1.3	16	7
Total	--------	872	873	--------	708	228	--------	289	1,011

[a] Ponds A–1 and A–2 continuous. [b] Also four *A. philippinensis* larvæ. [c] Dry, no collection.

TABLE 4.—*Salt content and collections of Anopheles larvæ in individual ponds*—Continued.

Date.	Pond P-2.			Pond C-4.			Pond C-3.		
	Salt content.	Larvæ.		Salt content.	Larvæ.		Salt content.	Larvæ.	
		A. litoralis.	*A. indefinitus.*		*A. litoralis.*	*A. indefinitus.*		*A. litoralis.*	*A. indefinitus.*
1931	*Per cent.*			*Per cent.*			*Per cent.*		
July 27	3.0	46	0	3.1	26	0	-------	([d])	([d])
Aug. 17	0.7	0	0	0.0	0	0	([e])	-------	-------
Sept. 3	1.1	0	0	1.1	0	0	([e])	-------	-------
Sept. 14	1.3	0	0	1.3	50	30	([e])	-------	-------
Sept. 24	1.1	0	0	1.3	88	43	1.1	31	22
Oct. 4	0.7	5	3	1.0	30	195	1.0	8	17
Oct. 14	1.0	3	1	1.1	8	39	1.1	34	32
Oct. 24	0.9	0	15	0.9	1	64	1.1	28	29
Nov. 3	1.0	0	2	1.1	1	61	1.0	12	26
Nov. 18	1.3	0	8	1.3	2	48	0.8	0	8
Dec. 16	1.7	0	11	1.6	13	46	([f])	-------	-------
1932									
Jan. 8	2.8	1	16	1.6	6	42	([d])	([d])	([d])
Jan. 22	2.7	3	14	2.8	4	69	([d])	([d])	([d])
Feb. 5	2.8	16	2	3.5	94	0	([d])	([d])	([d])
Feb. 19	3.8	60	2	4.2	90	0	([d])	([d])	([d])
Mar. 4	3.9	14	0	4.0	40	0	6.0	11	0
Mar. 18	5.2	22	0	5.5	26	0	5.4	68	0
Apr. 1	4.6	47	0	4.9	128	0	5.7	154	0
Apr. 15	4.3	34	0	4.6	85	0	4.9	3	0
Apr. 29	5.0	5	0	5.0	63	0	6.0	2	0
May 20	4.6	55	0	4.9	40	0	6.0	5	0
June 22	3.4	68	0	2.8	64	0	2.4	0	0
July 15	3.2	74	0	3.1	137	0	2.3	66	0
Total	-------	448	74	-------	946	637	-------	412	134

[d] No collection. [e] Ponds C-4 and C-3 continuous. [f] Pond drained and cleaned.

ANOPHELES BREEDING IN THE SALT AND BRACKISH-WATER PONDS

The almost complete elimination of *Anopheles* larvæ from the ponds in August gave an opportunity for a comparison of the oviposition tendencies of the two species and, as expected, the subsequent records showed a rapid increase in *A. indefinitus* larvæ. In addition, the observations led to two conclusions; first, that *A. litoralis* will oviposit in brackish or even fresh water when large numbers of adults are present and no other water is available; and second, that the larvæ are able to develop in such water. Of more especial interest, though, is the strong indication that the species is strictly salt-loving

TABLE 4.—*Salt content and collections of Anopheles larvæ in individual ponds*—Continued.

Date	C-2 (ditch).			C-1 (ditch).			C-0 (ditch).			Other ponds.		
	Salt content.	Larvæ.		Salt content.	Larvæ.		Salt content.	Larvæ.		Salt content.	Larvæ.	
		A. litoralis.	*A. indefinitus.*		*A. litoralis.*	*A. indefinitus.*		*A. litoralis.*	*A. indefinitus.*		*A. litoralis.*	*A. indefinitus.*
1931	*P. ct.*			*P. ct.*			*P. ct.*			*P. ct.*		
July 27	------	------	------	------	------	------	------	------	------	[h]3.1	3	0
Sept. 24	------	------	------	1.3	4	3	------	------	------	------	------	------
1932												
Mar. 4	3.2	8	0	2.7	15	0	6.7	28	0	------	------	------
Mar. 18	4.5	22	0	2.8	76	0	7.3	44	0	------	------	------
Apr. 1	4.4	37	0	4.2	95	0	8.8	75	0	------	------	------
	[g]7.0	146	0	------	------	------	------	------	------	------	------	------
Apr. 15	4.8	51	0	3.7	40	0	8.8	44	0	------	------	------
	[g]5.0	0	0	------	------	------	------	------	------	------	------	------
Apr. 29	6.0	100	0	4.8	109	0	4.6	76	0	[i]4.2	101	0
May 20	6.0	0	0	4.8	35	0	------	------	------	[j]4.6	149	0
June 2[illegible]	3.0	80	0	------	------	------	3.7	0	0	------	------	------
July 15	2.8	24	0	------	------	------	3.1	0	0	------	------	------
Total	------	468	0	------	374	3	------	267	0	------	253	0

[g] From pond. [h] Pond B. [i] Pond A-3. [j] Pond P-1a.

and would not maintain itself indefinitely under these conditions. Table 3 shows that, after a partial resumption of breeding, the larvæ gradually decreased until they had nearly disappeared, and were not found in abundance until the salt content in some of the ponds reached about 3 per cent. On another occasion, later in the season, when the concentration ponds were again breeding *litoralis* in numbers, the sudden appearance of the larvæ in pond A–1, where the water contained only a small amount of salt, may be attributed (if the record is not in error) to the cleaning out of the algæ in the salt ponds, which occurred at about this time in preparation for the manufacture of salt.

At the beginning of the study no feasible method of accurately determining the comparative abundance of the larvæ was found, since the counting of larvæ per dip or per unit area was not applicable to the conditions. A small clump of algæ might be the only breeding spot in a large area and contain very many larvæ per square foot, whereas a pond half covered with algal mats would ordinarily have more-scattered breeding but a much greater total output. In making the

collections, therefore, the attempt was made mainly to obtain a fair sample of the larvæ present.

In Table 3 the data have been arranged to show the total numbers of each species collected throughout the season and the average number per collection in the ponds where the collecting was carried out more or less uniformly. The rates per collection have been charted in text fig. 2 for comparison with the maximum and minimum salt percentages to show the general trend of conditions. The increase and decrease shown from one collection to another, however, may or may not accurately represent changes in the amount of breeding. The almost constant decrease in number of *Anopheles indefinitus* larvæ between October 4 and November 18 was not, apparently, an actual decrease in the total number of larvæ, since the notes for nearly all the collections during this period state that larvæ were plentiful. It probably does, nevertheless, represent a significant decrease in the number of fourth-instar larvæ and pupæ, since the younger larvæ were not identified, and no especial effort was made to rear these through to maturity in the laboratory. The plant growths found in the fresher water were not as a rule sufficiently thick to give complete protection, and the change perhaps reflects the effect on the larger mosquitoes of an increase in small fish and other natural enemies. The drop in number between October 4 and 14 was due mostly to the decrease of larvæ in pond C–4, for which the notes give no explanation. This is also the case for certain other variations in individual ponds. The sharp rises of the curves for both *Anopheles litoralis* and *A. indefinitus* April 1 and for *litoralis* July 15 were probably due, in part at least, to the collection of unusually large samples.

The rapid increase in *A. litoralis* breeding after January 22 is clearly correlated with increases in salt percentages. The line representing the increase crosses the maximum-salt-percentage line at about 3.3 per cent, and general increased breeding of this species probably began at about 3 per cent. After breeding had been resumed in the salt ponds, larvæ appeared in one of the brackish ponds (A–2) at less than 2 per cent and, as previously mentioned, another pond (A–1) showed a sudden influx of *A. litoralis* with only 0.9 per cent salt.

The falling line representing the decrease of *A. indefinitus* between April 1 and 15 crosses the minimum-salt-percentage curve at about 2 per cent. On the latter date one of the two remaining brackish-water ponds had become almost dry, the

other one (A–1) showing an increase in salt percentage to 2.3, from 1.4 April 1.

The maximum salt percentage at which larvæ of *Anopheles litoralis* were found breeding was 8.8. This occurred in the ditch at the edge of the salt-bed pond (C–0) April 1 and again April 15, and on both occasions the larvæ and pupæ were normally active. The absolute tolerance of the species for salt was not determined. A reading of 9.2 was recorded in pond A–2 May 20, and on this occasion larvæ were not present, but they had also been lacking in the pond at the time of the previous collection when the salt content was 6.6 per cent. Algæ, principally *Lyngbya majuscula* with a little *Chaetomorpha*, were plentiful on both dates.

In this connection it is of interest to note that the larvæ in the higher concentrations showed a curious thickening or encrustation of the epidermis. The larval hairs also appeared to be more brittle, and the specimens usually arrived in the laboratory with hair tufts and float hairs broken off.

Larvæ of *A. indefinitus* were taken on one occasion at a salt reading of 3.0 per cent and another time at 3.8. At both times the ponds were gradually evaporating, indicating that a small proportion of the larvæ could tolerate percentages above 3 under such conditions. So far as these records are concerned, breeding of *indefinitus* was completely interrupted for at least two months and no other breeding place for the species in this vicinity was known to us.[6] Nevertheless, adults were evidently on hand to restock the ponds as soon as conditions became favorable.

As a further comparison of the distribution of the two species, Table 5 shows the average number of specimens identified and the number of times that each species was taken at different salt percentages.

SUMMARY

In connection with a study of *Anopheles litoralis* King and *A. indefinitus* Ludlow, the two Philippine species of *Anopheles* that breed in salt water, larval collections were made in a series of ponds near Manila over a period of twelve months. The data obtained show that the optimum breeding conditions for each species occur at a different range of salt concentra-

[6] *Anopheles indefinitus* is commonly found in strictly fresh-water breeding places, inland. This phase of the subject has been discussed in the article by King previously cited.

TABLE 5.—*Number of collections and average numbers of the two species of Anopheles at different salt percentages.*

Salt content.	Number of collections containing—				Average per collection.[a]	
	A. litoralis only.	Both species.	*A. indefinitus* only.	No larvæ.	*A. litoralis.*	*A. indefinitus.*
Per cent.						
0.0–0.9	1	10	30	4	4.9	43.3
1.0–1.9	1	22	6	5	22.5	36.8
2.0–2.9	7	5	1	1	42.9	7.9
3.0–3.9	13	2	0	1	65.5	0.7
4.0–4.9	21	0	0	----------	71.8	0.0
5.0–5.9	6	0	0	1	66.8	0.0
6.0–6.9	8	0	0	2	52.8	0.0
7.0–7.9	2	0	0	----------	95.0	0.0
8.8	2	0	0	----------	59.5	0.0
9.2	0	0	0	1	----------	----------
Total or average----------	61	39	37	15	36.7	21.6

[a] The averages were figured from the number of collections containing larvæ of either species.

tions, which in turn vary with the seasons. This accounts for the marked seasonal fluctuations in the abundance of the two species.

Anopheles litoralis is predominant during the dry season, when the salt concentration is high, and is strictly a salt-water breeder, doing best in water containing upwards of about 3 per cent. Below this point breeding tends to diminish sharply and, although larval development took place under certain conditions in water containing less than 2 per cent salt, the evidence points to the probability that the species would ultimately become eliminated at low salt concentrations. During the rainy season the larvæ were gradually reduced almost to the vanishing point, and after the beginning of the dry season general increased production was not resumed until the salt content reached a point between 2.5 and 3.0 per cent.

The maximum salt concentration in which breeding of *A. litoralis* was found was 8.8 per cent. This was recorded twice, and on each occasion fairly large numbers of normally active larvæ and pupæ were present. Larvæ in the higher concentrations had a curious thickening or encrustation of the epidermis.

During the rainy season *A. indefinitus* becomes the predominant species, and the breeding of this mosquito is very largely limited to brackish and fresh water. At a time when the salt concentration was being gradually increased by evaporation, a

few larvæ were taken from water containing as much as 3.8 per cent, but in general the tolerance of the species is considerably less than this. Breeding in the ponds was entirely suspended for two months during the height of the dry season. After the beginning of the second rainy season, the larvæ reappeared in the first ponds showing a drop in salt content below 2 per cent.

The two principal kinds of algæ found in the salt-water ponds were *Chaetomorpha* sp. and *Lyngbya majuscula*. These formed large floating mats, especially in the salt-concentration ponds and fishponds, and flourished in water containing as much as 9 per cent of salt. The growths usually contained *litoralis* larvæ, but both kinds of algæ persisted to some extent after the ponds had been much diluted by rains and were then associated with *indefinitus* breeding. A third species of algæ, *Lyngbya aestuarii*, appeared to thrive best in water of lower or intermediate salt concentrations and disappeared from the ponds during the latter part of the dry season. Large mats were found when conditions were favorable. A fourth species, *Enteromorpha tubulosa*, was rather frequently recorded, being found at one time or another in each of the ponds and under a wide range of salt percentages. This species does not, however, form extensive growths and was much less important in connection with mosquito breeding.

In brackish-water ponds the most typical plant growth was a *Chara*-like plant belonging to the frogbit family (Hydrocharitaceæ). In water of low salt content it frequently developed luxuriant and extensive growth with the tops of the plants, resting just at the water surface, harboring large numbers of *Anopheles indefinitus* larvæ. The limit of salt tolerance of this plant species seemed to be between 2.5 and 3.0 per cent.

ILLUSTRATIONS

[The photographs, with the exception of Plate 2, were taken June 27, 1932, when the ponds were filled with water.]

PLATE 1

The series of concentration ponds, photographed from the edge of salt bed C–0.

PLATE 2

One of the paved salt beds from which salt is collected after evaporation of the sea water.

PLATE 3

One end of pond C 4 with scattered mats of algæ, *Lyngbya majuscula* and *Chaetomorpha* sp.

PLATE 4

Brackish-water pond A–1, the smallest of the ponds in the series. The pond contained a growth of the *Chara*-like plant, which is hardly visible in the photograph.

PLATE 5

Pond A–2, showing a large mat of algæ consisting almost entirely of *Lyngbya majuscula*.

PLATE 6

A portion of fishpond P–2, with a large mat of algæ in the foreground. Pond P–1 lies just beyond the dike at the far end.

PLATE 7

Pond P–1, flooded from June rains. A few tufts of grass and, in places, the tops of the *Chara*-like plant are visible.

TEXT FIGURES

FIG. 1. A sketch of the ponds where *Anopheles*-breeding studies were made, showing their approximate size and location.

2. The salt content and the seasonal abundance of larvæ of *A. litoralis* and *A. indefinitus* in six ponds under observation from July, 1931, to July, 1932. The circles on the lines representing maximum and minimum percentages of salt do not coincide with the dates of observation, which were the same as those for the larval collections.

PLATE 1.

PLATE 2.

PLATE 3.

PLATE 4.

PLATE 5.

PLATE 6.

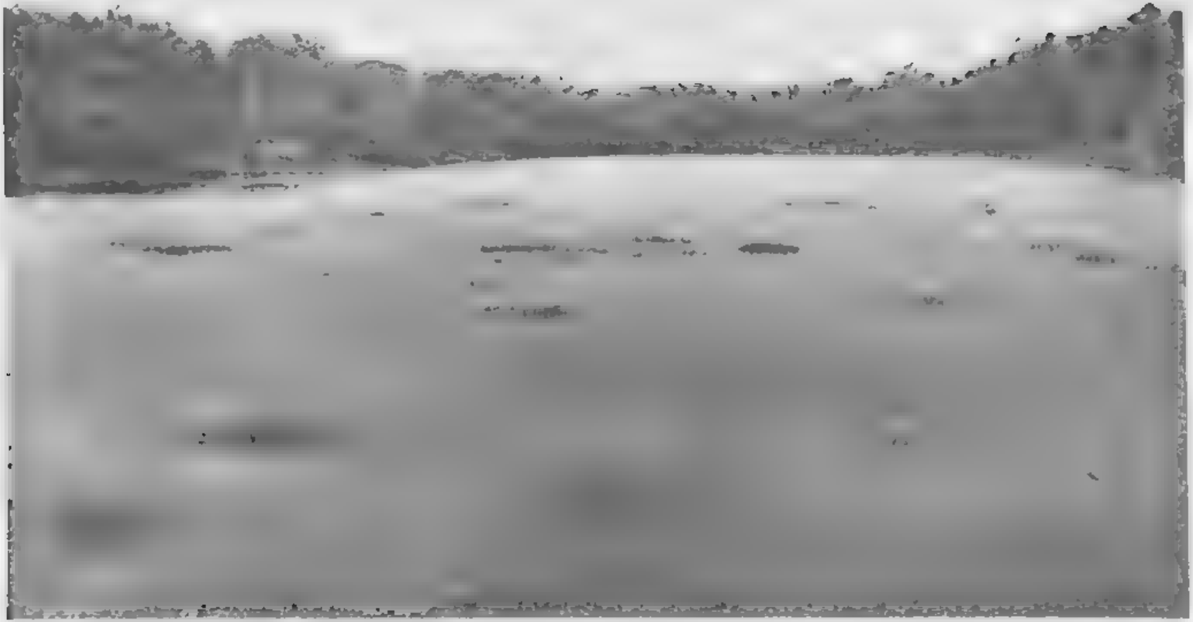

PLATE 7.

NEW OR LITTLE-KNOWN ORIENTAL THYSANOPTERA

By H. PRIESNER

Of the Ministry of Agriculture, Cairo, Egypt

This paper is based on material forwarded to me by Dr. R. Takahashi, of the Taihoku Agricultural Experiment Station. Most of the species were collected by Doctor Takahashi, who has contributed much to our knowledge of tropical Thysanoptera.

THRIPIDÆ

BERCINOTHRIPS ERRANS (Williams).

Male (hitherto unknown).—In every respect very similar to the female but slenderer; abdomen narrow, tapering from segment 1 or 2 caudad; the dorsal longitudinal pits at base of tergites as in the female; segments 7 and 8 each provided with a dotlike glandular area, the width of which is 16 and 22 μ, respectively. Tergite 8 with a long comb, which extends considerably beyond base of tergite 9; this segment longish, dorsal length, 140 μ; width beyond base, 136 μ; netlike sculpture of tergite 9 largely developed, particularly near the fore angles; dorsally and mesally the tergite bears two pairs of spines and two pairs of bristles; length of anterior pair of spines, 36 to 40 μ, of posterior, about 28 μ; posterior spines closer to each other than anterior; the two pairs of dorsal bristles situated near the sides of posterior spines; a short longitudinal furrow between anterior spines; between the posterior spines, however, there are eight to ten chitinous wartlets; tergite 10 consists of two rhomboidal plates. Measurements of the antennæ from joint 2: 42, 62 to 64, 56, 43, 28 to 29, 11, 28 to 29 μ.

FORMOSA, Kahodai, June, 1933 (*R. Takahashi*).

SERICOTHRIPS TABULIFER sp. nov.

Belonging to the group having two-colored abdomen, and margins of prothorax with netlike structure.

Female.—Much shaded; more or less dark brown as follows: Head, central plate of prothorax, femora (except extreme base and apex of fore and middle femora), notal plates of pterothorax (where not reticulated), mesosternum, metasternum, coxæ, a

small lateral plate on each of tergites 2, 3, and 6, and segments 7 to 9 and base of segment 10 of the abdomen. Pale yellow as follows: Entire tibiæ and tarsi; joints 1, 2, and 3 of antennæ; joint 3 sometimes very faintly shaded, 4 slightly shaded in apical half or third, 5 shaded about the apical half, 6 pale at base, the remainder of 6 and joints 7 and 8 slightly shaded; abdominal segments 4 and 5 pale yellow; segment 10 yellow, somewhat shaded; segments 2, 3, and 6 (excepting their dark dorsolateral plates) only slightly darkened; wings much darkened but with pale subbasal band. Bristles of the body shaded. Ocelli red, eyes black.

Head strongly transverse, its base almost behind the eyes, netlike space of hind margin of vertex extremely narrow, almost wanting. Length of eyes, about 60 μ. Bristles on head fine but distinctly visible; postocular series exactly on hind margin of vertex; interocellar bristles in front of hind ocelli. Length of head, 78 μ; width, 165. Antennæ very slender; measurements of joints: 24 (28), 36 (25), 76 (17), 68 (16), 44 (15), 56 to 60 (14), 10 (6), 12 (3) μ; joint 3 elongately bottle-shaped, but neck not narrowed at extreme apex—that is, not concave—joint 4 similar, both with long forked trichomes, length (on joint 3) 60 μ; joint 6 not constricted at base, with a long, narrow, pale longitudinal area, style very slender. Pronotum length (including netlike part), 96 to 100 μ; breath, about 190; polygonal reticulation of anterior and lateral parts dark, areas between meshes pale yellow; length of the anterior reticulated part, 36 μ—that is, 0.36 of the pronotal length—reticulated area with thin bristles on fore margin, the innermost longest, 24 to 26 μ; strongly chitinized, transversal dorsal plate of pronotum about 160 μ wide, and 60 to 64 μ long, with dense cross wrinkles, its fore angles about rectangular, not protruding—not as, for instance, in *S. ramaswamiahi* (Karny)—and its fore margin not deeply but only slightly emarginate; fore margin of reticulated part entirely straight; fore margin of dorsal plate set with well-developed but tender bristles (26 to 28 μ), a long angular bristle (about 36 μ) on the hind angle of the plate, at the hind margin; within, a distinct bristle. Pterothorax width, about 225 μ. Sternum, mesosternal metasternal plate, and coxæ smooth, in contrast to pleuræ, which are reticulated; mesoscutum densely cross-wrinkled, metascutum smooth. Abdomen peculiar in structure; slightly shaded tergites 1 to 3 densely set with microsetulæ and in addition a lateral, approximately semielliptical plate, the fore margin of which is sharply

lined with black; tergites and sternites 4 and 5 colorless, in contrast with segment 6, which is as in 2 and 3; 7 to 9 uniformly dark, with a more or less dark line on fore margin; segment 10 paler again. Bristles on segment 9 moderately long, bristle 2, 52 μ; on segment 10, about 60. Upper vein of the narrow forewings with 21 to 24 bristles; imaginary lower vein has no bristles. Total body length, distended normal, 0.98 mm.

FORMOSA, Loochoo (Oriomote), July 20, 1932, on *Glochidion* (?), 1 female (holotype) (*S. Minowa*).

This new species is closely allied to *S. circumfusus* Priesner, but differs in that in the latter the pale fore margin and lateral part of the pronotum are not reticulated but transversely striated, and the dorsal plate bears a greater number of bristles. Moreover, the bristles on the abdomen are longer, the antennæ darker, and their joints shorter. *Sericothrips ramaswamiahi* (Karny), another related species, has not polygonal, but transversely much distended, meshwork, and the head shows a pale, reticulated occipital portion, while the fore angles of the dorsal plate of the pronotum protrude hornlike. *Sericothrips occipitalis* Hood has the occiput reticulated, and the anterior part of the pronotum is more as in *S. ramaswamiahi*, and the fore margins of tergites 2, 3, and 6 are provided with a complete, uninterrupted, dark line. All the other species of this genus are quite different.

The new species is no doubt closely related to species of *Hydatothrips* Karny and *Neohydatothrips* John. The former genus will always be doubtful; it is based on a mutilated specimen; the latter genus is distinguished from *Hydatothrips* and *Sericothrips* only by the alleged characteristic striation of tergites 1 to 5 (microsetulæ?); in any case, *Neohydatothrips latereostriatus* John is easily distinguished from this new species by the much shorter antennal segments.

DENDROTHRIPS MINOWAI sp. nov.

Female.—Reddish brown, with irregular brown shadings; red pigment profusely developed but for a broad median longitudinal line, and the three terminal segments, which are free from red cells, less heavily chitinized and, therefore, paler; margins of vertex paler around eyes, undulated hind marginal line of vertex blackish, segment 10 of abdomen paler than 9; forelegs lighter than middle and hind legs, the former grayish yellow-brown, margins of tibiæ darker, particularly from middle to tip, lighter at base; middle and hind femora dark, darker than head and

prothorax; tarsi pale yellow to pale yellowish gray; antennal joint 1 grayish yellow exteriorly, 2 shaded, 3 to 5 pale yellow, 5 shaded in distal half or at apical margin, the following joints dark. Forewing, including scale, deeply shaded with gray, with a single colorless band before middle, separating a dark basal part about 208 μ long, from a hyaline portion 120 μ long; the remainder about 390 to 400 μ. Bristles pale.

Head strongly transverse, length from eyes, 80 μ; entire length, 88; width, 156; width of interantennal projection, 12 to 14, the latter truncate in front; head between the eyes with a double excavation; cheek narrowed posteriorly; length of eyes, dorsally, 64 to 68 μ; laterally, 60; facets coarse, intervals hardly pilose; a less strongly chitinized, transversally wrinkled, postoccipital part separated from the vertex by a dark crossline; no conspicuous bristles on head; two very small pores on either side in front of the posterior ocelli, suggesting vestigial bristles. Mouth cone very short, and broadly rounded, maxillary palpi most probably two-segmented. Antennæ short, about 200 μ; measurements of joints, as follows: 14 to 17 (25), 34 (25 to 27), 36 (15), 32 (15), 34 (16), 27 to 28 (11), 8 (5), 8 (3) μ; joint 1 somewhat widened towards apex; 2 barrel-shaped, narrowed, basally and apically, more noticeably convex interiorly than exteriorly, transversely striate, bearing microsetulæ; joints 3, 4, and 5 slender, 3 with thin stalk, sense cones on joints 3 and 4 small, simple; joint 5 thicker and longer than 4 and much stouter than 6; this joint spindle-shaped, style slender, thin; sense cone of joint 6 long and thin, surpassing tip of antenna. Prothorax strongly transverse, length, about 92 μ; width, 183; fore margin straight, hind margin somewhat rounded; surface without any particular structure, irregularly and obsoletely rugose. Prothorax without conspicuous bristles. Legs, especially fore tarsi, short. Width of pterothorax, 225 to 232 μ; length of wings, 0.73 to 0.74 mm; shape of wings as in other species of this genus, hind margin straight; fore and hind margins fringed, but fringe developed on the former from the white crossband only; thus about the basal third of the wing remains free from fringe hairs; these hairs inserted on fore margin, not at the edge itself, but somewhat remote from it, at the lower surface of the wing; only one inconspicuous longitudinal vein; hind wings very narrow. Abdomen with dorsal longitudinal furrow from segment 2 to 7, in which is situated the usual pair of bristles; laterally, on both sides of this furrow, surface transversely striate, the faint crosslines provided with extremely small

somewhat longish in appearance; interocellar bristles in normal position (situated on the tangent), moderately long (28 μ); postocular series, none of which is particularly prominent, close to hind margin of eyes, horizontal, the two innermost bristles situated behind hind ocelli. Length of antennæ, 415 μ; measurements of joints: 20 (36 to 38), 42 (31 to 32), 93 to 95 (31), 106 (29), 56 (20), 62 to 64 (17 to 18), 11 (8), 17 (6) μ; joint 1 strongly transverse, 2 normal, 3 and 4 very long, bottle-shaped, with a long necklike apical part, and very long sense cones (88 to 96 μ), which reach the middle and the terminal third of the following segment, respectively; sense cones on joint 6 slender; joint 5 even somewhat broader than 6, broadest at apex, while 6 is broadest at base, and very little longer than 5; base of joints 4 and 5 as in *Cricothrips* Trybom. Length of pronotum, 155 to 173 μ; width, 216 to 240; disk of pronotum transversely striate as the vertex; a single long posteroangular pair of bristles (the inner), about 76 to 80 μ; the outer pair does not exceed 28 μ, and is not longer than the anteroangular and laterals; disk well set with small bristles; two pairs of posteromarginals are noticeable, the innermost of which is about 36 μ in length. Width of mesothorax, 311 to 360 μ. Wings, length about 0.95 mm; ensiform, broad near base but much narrowed beyond (130: 52); upper vein with numerous (3 or 4 + 7; 4 + 6) basal, and 1 + 2 distal bristles, lower vein with 13 to 17 bristles, costa with about 30. Accessory bristles wanting on sternites; a long, complete comb on tergite 8. Bristles on segment 9, dorsals 68, posteromarginals 132 to 136, 160, 160 μ; those on segment 10, 148 to 152, 144 μ; segment 10 not divided above. Total body length (distended), 1.67 mm.

FORMOSA, Hori, June 6, 1933, 1 female; August 9, 1934, 2 females in orchid flower (*R. Takahashi*). Previously known from Java.

This is one of the few species of the genus *Tæniothrips* having only one well-developed bristle at the hind angles of the prothorax; the dark basal ringlet of each of antennal joints 4 and 5 also suggests *Cricothrips* Trybom, a genus which is not yet definitely characterized and well separated from *Tæniothrips* sens. lat., since, in the above character, there are gradations from *Tæniothrips* to *Cricothrips*. Moreover, the chætotaxy of the prothorax brings the species close to *Oxythrips*, and I should not wonder if it would be described once more under the latter genus.

TÆNIOTHRIPS SULFURATUS sp. nov.

Female.—Pale yellow, thorax and extreme tip of abdomen conspicuously tinted with orange, exactly as in *Thrips flavus* Schrk., no trace of gray shades on the body; eyes dark purple, ocelli crimson, bristles on the body dark. Wings almost colorless, very faintly shaded with yellow; legs yellow. Antennal joints 1 and 2 pale yellow, the latter often with orange (not grayish), the following clouded with gray, 3 yellow about the basal third or basal half, 4 uniformly or only basally yellow, 5 yellow in basal half, 6 dark or somewhat paler at base, style dark.

Very similar to the eight-segmented form of *T. flavus*,[1] so that the bristles of the head are equal in length and position, only the disk bristles of the pronotum are set more densely and closely than in *T. flavus;* hind angular bristles, about 80 μ long (100 to 105 μ in large specimens of *T. flavus*); hind margin with three pairs of smaller bristles, the innermost, 36 to 40 μ, as in *Thrips flavus.* Width of mesothorax, 240 to 286 μ; length of wings, 0.81 to 0.95 mm. Costa with about 30 bristles, upper vein with 7 basal and 1 + 2 distal bristles, lower vein with about 15 to 16 bristles. Antennæ somewhat more slender than in *T. flavus*, thus they differ not only in their color. Antennæ with style very short, joints 7 and 8 little different in length; measurements of joints from joint 2: 45 (25), 67 (20), 62 to 66 (18), 45 (18), 64 to 66 (19), 6 (7), 7 (6) μ; a smaller specimen has joints 3 to 5, 56, 42, and 55 μ, respectively. No accessory bristles on the sternites; tergite 8 with complete comb; bristles on segment 9, bristle 1, 92 μ; bristle 2, 112 to 120; bristle 3, 104 to 108; segment 10, bristle 1, 120 μ; bristle 2, 112 (bristle 1 of segment 9 much longer in *T. flavus*).

FORMOSA, Taihoku, May 3, 1933, female, holotype, on *Clerodendron;* November 25, 1933, females, paratypes, on *Camellia;* Matsumine, Taichu-Shu, August 12, 1934, female, paratype (*R. Takahashi*).

[1] Bagnall, Ent. Mo. Mag. 44 (1928) 98, described a *Physothrips flavus*, which is distinguished from *Thrips flavus* Schrk. only by the two-segmented style. This, however, cannot be a new species of *Tæniothrips* (*Physothrips*), but must be a regressive form of *Thrips flavus* and has to be dealt with as such, and a new name has to be created for it (for example, *biarticulata*) or it has to be mentioned as "forma," even without a special name, with *Thrips flavus* Schrk. When making a key for the species of *Tæniothrips* (*Physothrips*), one has, of course, to include this form of *Thrips flavus*, but under the latter name; not as *Tæniothrips*.

BOLACOTHRIPS ORIENTALIS sp. nov.

Male.—Light yellow, eyes dark purple, testicles orange; legs pale yellow, joints 1 to 4 of the antennæ pale yellow, joint 5 grayish, paler towards base, 6 and 7 dark. Bristles almost colorless.

Head, length, 124 μ; from eyes, 108; width across eyes, 112 to 120; eyes, length about 56; fore angles of eyes somewhat distant from base of antennæ; ocelli not noticeable, apparently absent; interocular bristles well developed, about 28 to 32 μ in length; a small anteocular near fore angles of eyes; a very small posterior interocellar bristle, hardly longer than the inner postocular bristle; there are only two pairs of postoculars discernible, the inner of which is very minute, the outer, however, very well developed, about 32 to 36 μ; mouth cone as usual; length of antennæ, 225 μ; measurements of joints: 18 to 20 (25), 34 (22), 36 (17), 31 to 32 (15), 34 to 35 (14), 45 to 46 (15), 15 to 17 (8) μ; joint 1 convex laterally, the sense cones on segments 3 and 4 apparently simple, joint 5 broad at apex, 6 little rounded laterally. Prothorax narrow, 112 to 120 μ in length, 132 μ in width; bristles tender, bristles 2 of fore margin 24 to 28 μ, posteroangulars 56 to 60 and 40 to 44 μ; three pairs of posteromarginals, the innermost 15 to 20 μ. Pterothorax width, 148 μ; wings reduced to small scales, bearing five costal (marginal) bristles; segment 9 of the abdomen with very long bristles: there is one dorsal pair of about 116 to 120 μ, while a posterior median pair measures not more than 36 to 40 μ; bristle 2 (lateral) is even 136 μ. No comb on tergite 8. Sternites 3 to 7 with large and broad glandular areas (width, 72 to 76 μ; on segment 7, 68 μ), the fore margins of which are nearly straight, the hind margins somewhat emarginated. There are accessory bristles behind the glandular areas, being most numerous (6 or 7) on segment 6, least (2) on segment 5.

FORMOSA, Taihoku, August 4, 1934, 1 male, on onion (*R. Takahashi*).

This species is very similar to *B. jordani* Uzel, but differs in the shape of the antennæ and their coloration, the broader glandular areas, and the chætotaxy of tergite 9, of which the innermost pair of bristles is much smaller than the outwardly following one, while in *jordani* the first (innermost) pair is longest (120: 32 μ). The female is unknown.

PHLÆOTHRIPIDÆ

LIOTHRIPS HEPTAPLEURINUS sp. nov.

Female.—Black, middle and hind tarsi gray-brown, fore tarsi pale yellow, fore tibiæ brown-yellow, somewhat shaded at margins towards base; joints 1 and 2 of antennæ dark, 2 yellowish brown towards apex (outwardly), 3 to 6 clear yellow, 6 scarcely noticeably clouded towards tip or wholly yellow, 7 and 8 pale brown, 7 almost clear at base. Wings colorless, with a faint longitudinal streak, reaching the distal third. Bristles of body black, much paler on segment 9.

Head, length, about 277 to 310 μ; breadth, 200 to 208; cheeks parallel, somewhat constricted at base, head not broader across eyes than behind; eyes laterally 95 μ, the posterior ommata not larger than the others; hind ocelli before middle of eyes, front ocellus somewhat surpassing the fore margin of the eyes. Bristles on body pointed. Postoculars very long, black, longer than an eye. Mouth cone long, pointed. Length of antennæ, 484 to 520 μ; measurements of joints: 40 (bristle 48, t. 38), 60 to 64 (36), 92 to 94 (34), 88 (40), 76 (36), 68 to 70 (34), 62 (28), 38 (15) μ; sense cones, joint 3, 1; joint 4, $1 + 2^{+1}$; joints 5 and 6, $1 + 1^{+1}$; joint 3 is 2.6 to 2.7 times as long as broad, 8 narrower than 7 at apex, but not constricted, hardly narrowed towards base. Pronotum, length, 155 to 190 μ; width, including coxæ, 355 to 415; fore angle bristles conspicuous, about 80 μ or more, both pairs of posteroangular bristles 173 to 182 μ, their width at base, 6 μ; length of coxals, 72 to 80 μ; these bristles are sharply pointed. Width of pterothorax, 415 to 485 μ. Bristles at base of wings black, length, about 92 to 96 μ, almost pointed; wings broad, parallel-sided, with 14 to 16 double fringe hairs. Lateral abdominal bristles stout, long, dark; those on segment 9 yellowish, very long, 220 to 240 μ; anals, 220. Tube, length, 260 μ; breadth at base, 100; breadth at tip, 50; conical, sides straight, sometimes more strongly constricted about the apical third. Total body length, 2.55 mm.

FORMOSA, Taihoku, December 23, 1926, on *Heptapleurum* (*R. Takahashi*).

One might compare this species with *Smerinthothrips heptapleuri* (Karny); but the latter species has, apart from the blunt mouth cone, a shorter third antennal joint, shorter legs, and much shorter bristles, and the wings are slightly clouded throughout; there is no other species of *Smerinthothrips* with which it could be confused; from the allied species of *Liothrips* the new

species differs as follows: From *L. oleæ* (Costa) by the longer tube, the striped wings, the longer bristles, and the lighter antennæ; *L. kingi* Bagnall has very short, colorless postoculars; *L. malloti* Moulton has a much shorter tube; and *L. longirostris* Karny has the inner anteroangulars of pronotum vestigial and the wings shaded throughout. There is only one species really similar to *L. heptapleurinus;* namely, an undescribed form from India, collected by Dr. Ramakrishna Ayyar (Coonoor, December, 1927, No. 194), which I have not at hand at present, but I have a short description and the measurements of the antennæ; however, the antennæ are not only absolutely longer but the third joint is more elongate, 3.7 to 3.8 times as long as broad, while it is only about 3 times as long as wide in *heptapleurinus;* the head is 380 (225) μ in length and 225 μ in breadth, the tube 277 μ; the Indian species shows the following measurements of the antennal joints, from 3: 120 (32), 115 (41), 106, 81, 64, 32 μ. It is certainly different.

LIOTHRIPS PIPERINUS sp. nov.

Female.—Blackish brown to black; extreme tip of fore femora, fore tibiæ, all tarsi, and tips of middle and hind tibiæ pale yellow; antennæ with joints 1, 2, 7, and 8 dark, 3 and 4 yellow, 5 yellow, slightly shaded in distal half (or two-thirds), 6 shaded in apical half. Forewings slightly clouded, besides, with a long, dark streak, and with hind margin gray, hind wings with a longitudinal streak, and hind margin shaded.

A large species, with legs and antennæ slender, bristles long and very stout.

Head, length, 380 μ; from eyes, 355; width across eyes, 234; eyes large, 130 to 138; length of cheeks behind them, 225; cheeks converging posteriorly; hind ocelli well before middle of eyes; postoculars stout, dark, blunt, 112 to 120 μ, their distance from the eyes, 44 to 48; mouth cone long and narrow, labrum sharply pointed. Antennæ, length, 623 to 640 μ; measurements of joints: 40 (bristle 48), 68 to 76 (32 to 36), 100 to 108 (32), 112 to 120 (38 to 40), 112 to 120 (32 to 33), 92 to 100 (32), 76 to 80 (24 to 26), 40 to 44 (12 to 13) μ; joint 3 with one long and very slender sense cone, joint 4 with $1 + 2^{+1}$, 5 with $1 + 1^{+1}$; forelegs slender. Length of prothorax, 173 μ; width, 363; including coxæ, 424; bristles very well developed, length of those on hind angles, about 155 to 160 μ; their diameter at base, 8; they are blunt at tips; anteroangulars, about 65 μ. Pterothorax width, 467 to 520 μ; wing, length, about 1.38 mm; bristles at base

of wing dark, 100 μ; bristle 3, 140 μ; the latter almost pointed. Double fringe 17 μ (in a very small specimen, 11; mesothorax, 346). Bristles on abdomen stout, dark, bristles 1 and 2 on tergite 9 sharp, hairlike, 200 to 240 μ, while some of the dorsal bristles of the anterior segments are blunt. Tube regularly conical, length, 260 to 277 μ; width across base, 96 to 100; at tip, 46 to 48; lengths of anal bristles, 260 to 280 μ; dark at base only. Total body length, 2.85 to 2.94 mm.

FORMOSA, Habon, August 10, 1934, females on *Piper;* together with *Smerinthothrips kuwanai* (Moulton); Rarasan, July 31, 1933, on *Piper* (*R. Takahashi*).

The shape of the head, the comparative length of the tube, the color of the antennæ, and the distinct coloration of the wings exclude a great number of species from comparison; *L. oleæ* (Costa) has shorter and stouter legs and antennæ, and other coloration of the latter; *L. hradencensis* Uzel is similar but has the eyes much smaller, head and antennæ less slender, and mouth cone much less acute, bristles thinner, and wings paler; *L. seticollis* Karny is much closer in shape but has antennæ darker, middle and hind tibiæ and tarsi dark, and bristles not so stout; the new species is also quite close to *Smerinthothrips ficarius* (Priesner), but shape of mouth cone and color of tibiæ are quite different; the shape of the extremely stout bristles is about the same as in *Smerinthothrips rubiæ* (MS), from *Rubia cordifolia*, Mount Gedeh, Java, and also the antennæ are similar, but in *rubiæ* they are darker, even joint 3 is somewhat gray at tip, and the tube is different in shape, not evenly conical, and longer, mouth cone blunter.

DOLICHOTHRIPS PUMILUS sp. nov.

Male.—Blackish brown to black; legs dark, middle and hind tarsi shaded with gray, fore tibiæ dark at base and sides, yellowish longitudinally in the middle and at tip; antennæ with joints 1, 2, 7, and 8 dark, 7 sometimes pale at base, intermediate joints (3 to 6) pale yellow. Wings colorless or nearly so.

Head, length from eyes, 190 μ; total length, 202; width, 155 to 165; surface almost smooth (very densely and inconspicuously transversely striated); cheeks almost parallel; length of eyes, 80 μ; cheeks behind them, 120 to 128; hind ocelli situated before the middle of eyes, front ocellus somewhat overhanging; behind the posterior ocelli, at inner margins of eyes, two minute bristles on each side; postoculars very close (6 to 8 μ) to hind margin of eyes, 48 to 52 μ in length, blackish, sharp. Mouth cone acute-

ly pointed, sides concave; maxillary palpi slender. Antennæ, length, 329 to 337 μ; measurements of joints: 22 (bristle 28), 42 (24), 49 (27), 56 (28), 50 (22), 46 (20), 42 (17), 25 (10) μ; joint 1 narrowed towards tip, areola of joint 2 situated near apex, joint 3 more strongly convex inside than on the outer surface, with 1 + 2 sense cones, 4 with 2 + 2 sense cones, 5 with 1 + 1; joint 8 narrower than 7 at apex, but not constricted. Fore femora somewhat enlarged, fore tarsi with a triangular tooth at base; prothorax, length, about 125 μ; width, 234; width including coxæ, 253; bristles moderately long, dark, blunt or open, straight, those on fore margin not more than 28 μ, the posteroangulars, about 40 to 48 μ; coxal, 32, dark, blunt. Pterothorax, width, 294 to 303 μ; wings somewhat narrowed in the middle, basal bristles somewhat shaded, 1, 2 short, 28 to 34 blunt, bristle 3 acute, not longer, 32 μ; double fringe, 6 to 7. Segment 2 of the abdomen broadest, 240 to 277 μ; bristles on segment 9 of the abdomen rather pale, bristle 1, 128 to 132 μ; bristle 2, 20 μ, weak, not spinelike; bristle 3, about 140 μ. Tube shorter than these bristles, length, laterally, 128 μ; dorsally, 122; width, across base, 60; at apex, 32; terminal (anal) hairs about 180 to 188, shaded; tube conical, but somewhat more constricted before apex. Total body length, 1.45 to 1.64 mm.

Female.—Very similar to the male but somewhat stouter, fore tarsi also armed. Head, length, 218 μ; width, 164; mesothorax width, 329. Eight or nine interlocated fringe hairs. Bristles on fore margin of prothorax, 40 μ; those on segment 9 of the abdomen 180, 160, and 152 μ. Tube regularly conical; length laterally, 168 μ; width, basally, 72; across apex, 36; anals, about 200.

FORMOSA, Nisui, November 1, 1928, on *Diospyros discolor* (*R. Takahashi*).

The new species is distinguished from the other species of this genus as follows: *Dolichothrips citripes* (Bagn.), *D. flavipes* (Mlt.), *D. macarangai* (Mlt.), and *D. ochripes* Karny have yellow tibiæ; *D.* (*Dolicholepta*) *jeanneli* Bgn., *D.* (*D.*) *giraffa* Karny [= *micrurus* (Bagnall)], and *D.* (*D.*) *karnyi* Faure have simple fringe; *D.* (*D.*) *varipes* Bagnall has simple fore femora and legs and body, very slender fore tarsi unarmed in both sexes; *D. longicollis* Karny is a much larger species, with longer prothorax and black bristles on segment 9; the new species is very close to *D. indicus* (Hood) (= *Neoheegeria indica* Hood), in which species, however, joint 7 of the antennæ is pale, the postoculars are shorter, joint 4 of the antennæ only 1.8 times as

long as broad; that is, the antennæ are not so slender as in *pumilus*.

SMERINTHOTHRIPS VITIVORUS sp. nov.

Female.—Blackish brown to black, legs dark; tips of middle and hind tibiæ, and the fore tibiæ (except their base) pale yellow, tarsi light yellow. Bristles on head and prothorax blackish, those on the abdomen (excepting those on segments 2 to 4 and the dark anals) yellowish to grayish yellow; antennæ with joints 1 and 2 dark (the latter paler in distal half, exteriorly), joints 3 to 7 pale yellow, 7 diffusedly shaded in apical half or wholly pale, 8 brownish. Wings colorless or very slightly tinged with yellow.

Head longish, length, from eyes, 277 μ; total, 303; width, across eyes, 185; across cheeks, 196; eyes, 100; cheeks behind them, 188; cheeks parallel or very slightly widened posteriorly, surface somewhat roughened; just behind the eyes there is a very small notch, so that the cheeks begin somewhat angularly; postocular bristles black, moderately long, 60 to 68 μ, rounded at tip or blunt, far back, about 52 μ distant from posterior margin of eye; hind ocelli situated at anterior third of eyes, first ocellus somewhat overhanging; mouth cone broadly rounded, labrum blunt; antennæ, length, 484 to 528 μ; measurements of joints: 40 (bristle 44), 60 (36), 84 (32), 84 to 86 (38), 84 to 86 (34), 78 (34), 64 (28), 36 (18) μ; sense cones short, joint 3 with 1, joint 4 with $1 + 2^{+1}$, joints 5 and 6 with $1 + 1^{+1}$, joint 7 with 1d; joint 3 with lateral margins straight, 8 short, narrower at base than 7 at apex but not constricted. Fore femora somewhat larger than middle and hind femora but not incrassate; fore tarsi unarmed (in both sexes). Pronotum, width inclusive of coxæ, 372 μ; length, 138 to 147; anteromarginal bristles developed, blunt, length below 40 μ; hind angulars fairly stout, blunt, 100 μ, the inner pair much weaker, 60 μ. Pterothorax width, 398 to 450 μ; wings, length, about 1.03 mm. Ten to thirteen interlocated hairs; basal wing bristles rather pale, 52 to 56, 64 to 68, and 64 to 78 μ in length, all three blunt, their basal plate light. Bristle 1 of those on segment 9 of the abdomen about 224 μ, bristle 2 about 240, hairlike. Tube conical as a whole, somewhat more strongly constricted before apex, and with an indefinite slight concavity in basal third, length, 233 to 250 μ; width across base, 90 to 93; width at apex, 46; anal hairs, about 180.

Male.—There is no striking difference in the sexes; the single male before me has nine double fringe hairs, and bristle 2 of tergite 9 not thornlike, weak, 72 μ. Tip of penis bilobed. Head length, 277 μ; prothorax length, 120.

FORMOSA, Daibu, November 19, 1930, on *Vitis;* Sozan, August 2, 1934, on *Vitis* (*R. Takahashi*).

This species comes in the group of species having tube shorter than head and wings colorless, near *S. kannani* (Moulton), which has, however, middle tibiæ pale in distal half, and legs and antennæ slenderer; all the remaining species have long postocular bristles, except *S. moultoni* (Ram.); but this species has tube shorter (170 μ), and antennæ wholly yellow, head longer; *S. tropicus* Schm. has dark antennæ.

HAPLOTHRIPS (ODONTOPLOTHRIPS) DENTIFER sp. nov.

Male.—Dark brown, legs characteristically colored; fore femora brown, apical third pale yellow, middle femora dark, extreme apex paler, hind femora dark at the fore margin, the whole apical third, and the inner (hind) margin yellow-brown, similar to colors in *Neosmerinthothrips;* middle and hind tibiæ wholly dark, fore tibiæ yellowish brown, shaded with gray; joints 1 and 2 of the antennæ somewhat lighter than the head, brown, 2 yellowish apically, exteriorly, 3, 4, and 5 yellow, or 4 and 5 slightly clouded in apical half, 6 pale yellow, always shaded in apical half or third, 7 and 8 dark brown. Wings slightly but distinctly and uniformly shaded throughout their length. Bristles dark.

Head short, length, about 225 μ; including iap, 250; broadest across eyes, 183 to 192; eyes not protruding, their dorsal length (diameter), 95; their lateral length, 87; cheeks slightly rounded and converging posteriorly; surface of vertex somewhat indistinctly netlike; distance of postoculars from eyes, 20 to 24 μ; length, 88 to 96; these bristles nearly pointed or somewhat rounded at tip, which is colorless; mouth cone short, very broadly rounded. Antennæ, length, 450 to 467 μ; measurements of joints: 52 (bristle 46, 36), 60 (32), 76 (30), 72 (36), 60 to 64 (32), 56 to 58 (30), 44 to 50 (24), 34 (15) μ. Joint 1 narrowed towards tip, areola of joint 2 near apex; sense cones acute, joint 3 with 1, joint 4 with $1 + 2^{+1}$, 5 and 6 with $1 + 1^{+1}$, 7 with Id; joint 6 rather broadly truncate at apex, 8 as broad or almost as broad at base as 7 apically. Forelegs (male) strongly enlarged, fore tibiæ with a small tooth apically, fore tarsi with

a large, hooklike tooth, which emerges from a triangular base. Prothorax large, length, about 190 μ; width, 330; including coxæ, 390; median endothoracic thickening strong; bristles on the fore angles very small, external posterolateral bristles about 140 μ; practically pointed, the inner much smaller, 44 μ at the most; coxal bristles long, straight, 88 to 92 μ. Pterothorax width, 398 to 415 μ. Wing, length, about 0.95 mm; width in the middle, about 88 μ; double fringe, 13 to 15; bristles at base almost acute or pencil-shaped, 48, 76, and 72 μ. Bristles on abdomen pointed, long, bristle 1 on segment 9, 208 μ; bristle 2 (male), about 80, not spinelike; bristle 3, 232; all bristles grayish yellow. Tube, length, about 233 to 242 μ; its width across base, 92 to 96; at tip, 40 to 44; shape conical, tube somewhat thick at base, and constricted near apex; anals short, 140 μ. Segment 9 with scalelike appendix below. Total body length, distended, 2.35 mm.

Female.—Similar to the male in every respect, but prothorax smaller, its length, 155 μ; forelegs much less enlarged, fore tibiæ unarmed, fore tarsi with tooth much smaller. Head, 208: 190 μ. Tube as in the male, 234 μ.

LOOCHOO ISLANDS, Amami-Oshima, July 28, 1932, on *Ardisia* (*S. Minowa*).

This species is near *H. hadrocerus* (Karny), but areola of joint 2 is near the tip, while in *hadrocerus* it is in the middle of the joint; antennæ longer, tooth on the tibiæ developed only in the male. *Haplothrips dentatus* Priesner has three sense cones on joint 3 and four on joint 4 of the antennæ; *H. calcaratus* (Hood) is colored differently; the antennæ, especially, are much darker, with joint 3 pale only in basal half; head with lateral tubercles behind eyes; besides, the insect is apterous.

HAPLOTHRIPS CHINENSIS Priesner var. MONTIVAGUS var. nov.

Female.—Black, middle and hind legs black, including tarsi, fore femora, outer and inner margin of fore tibiæ black, the remainder grayish yellow; antennal joints 1, 2, 6, 7, and 8 dark, 3 clear yellow, 4 yellow but slightly clouded in distal half, 5 grayish yellow, shaded in apical half, 6 sometimes paler at base. Bristles dark, those on abdomen yellowish gray to gray. Wings clear, except for a faint shade about the median third.

Head normal, length from eyes, 225 μ; total length, 242; width across cheeks, 200; somewhat narrower across eyes, 194; cheeks gently converging posteriorly; eyes, length laterally, 84 to 86 μ; postocular bristles blunt, rather short, 48 μ, about 16 μ distant

from hind margin of eyes; mouth cone short, rounded; antennæ, 372 to 389 μ; measurements of joints: 36 (bristle 40, t. 30), 52 to 56 (32), 60 (28), 64 to 66 (37), 56 (32), 50 (26), 48 (22), 32 (13) μ; joint 1 strongly converging towards apex, 3 asymmetrical, slender, outer surface seen from above nearly concave, with 1 sense cone; 4 with $2 + 2^{+1}$ sense cones, 5 and 6 each with $1 + 1^{+1}$; bristles on prothorax blunt or open, those on fore angles quite well developed, the posteroangulars somewhat over 80 μ in length, about as in *H. gowdeyi* Frkl.; prothorax, length, 155 μ; width, including coxæ, 320; fore tarsi with a small tooth; pterothorax, 346 to 380 μ (in small specimens only about 311 μ); wings normally constricted, moderately broad, with basal bristles (56 to 64 μ) grayish, open,[2] fringe not pinnate, double fringe 8 to 11; bristles on segment 9 of the abdomen, bristle 1, 105, bristle 2, 128, weak, pointed; tube short, 0.73 the length of head; length, 160 to 168 μ; basal width, 72 to 76 μ; apical width, 38 μ; anal bristles, 184 to 232 μ.

FORMOSA, Mount Ari, April 24, 1931 (*S. Minowa*); Marikowan, August 11, 1934, on *Polygonum* (*R. Takahashi*).

I hesitate to describe this form as specifically different from *H. chinensis* Priesner; the latter has joint 3 of the antennæ almost evenly conical, postoculars longer, wings colorless, antennæ much paler, even joint 6 yellow (shaded apically); but it may be possible that these differences have a biological basis; moreover, *H. fumipennis* Priesner belongs to the same group, and all these will have to be studied closely when more material is available.

HAPLOTHRIPS ALLII sp. nov.

Female.—Gray-brown, tube darkest, body with rich crimson mesodermal pigmentation, turning into orange on metathorax; fore tibiæ pale yellow, shaded only at base, middle and hind tibiæ gray, pale yellow only in apical third; tarsi pale yellow; antennal joints 1, 2, and 8 dark, 3 to 7 pale yellow, 7 may be somewhat shaded. Bristles hyaline to pale gray, wings colorless.

Head longish, length, 208 μ; total length, 225; width across eyes, about 156; across cheeks, 182 (but somewhat diverging posteriorly because of being somewhat pressed); lateral length of eyes, about 70; cheeks behind them, 156; postoculars, which

[2] In the specimens from *Polygonum*, bristle 3 of the base of the wings is hairlike, pointed, about 100 μ in length; bristle 1 on segment 9 of the abdomen, 76 μ.

are dark in mature specimens, moderately long, 40 μ, knobbed, about 16 μ distant from hind margin of eyes; mouth cone rounded; measurements of antennal joints: 24 to 28, 48 to 52, 54 to 56 (27), 64 to 68 (28), 56 to 60 (25), 50 to 52 (24), 46 to 48 (22), 30 to 32 (12) μ; joint 8 distinctly narrower at base than 7 at apex but not constricted, joint 3 with 1 sense cone, joint 4 with 2 + 2; joint 3 slightly asymmetrical; pronotal bristles knobbed, the anteroangulars moderate, 24 μ; posteroangulars, 48 to 52; the inner, 44. Mesothorax, width, 260 to 295 μ; wings rather narrow, fringe not pinnate, no duplicated cilia; basal bristles of forewings knobbed, almost funnel-shaped, 28, 32, and 48 μ in length. Three pairs of colorless bristles on segment 9 of the abdomen, knobbed, bristles 1, 2, and 3, 88 to 92 μ; tube short, conical, length, 116 to 124 μ; width, across base, 56 to 58; across apex, 32; anals, 140 to 160. Legs slender, fore tarsi unarmed in the female. Male unknown.

FORMOSA, Sankaiseki, November 11, 1932, on onion (*Kay Sakimura*).

This species is nearest to *H. apicalis* Bagnall, but the head is much narrower, tibiæ yellow at apical third, legs slenderer, no tarsal tooth, and wings narrow. The appearance is rather that of an *Adraneothrips*.

NEOSMERINTHOTHRIPS FORMOSENSIS sp. nov.

Female.—Blackish brown to black, head paler, light brown, all femora brownish yellow, dark only at outer margins, fore tibiæ yellowish brown, shaded at margins, middle tibiæ more deeply colored, hind tibiæ dark; tarsi yellowish gray. Joints 1 and 2 of the antennæ palest, pale brownish yellow, 3, 4, and 5 with a diffuse tint of gray, 5 darkest, 6, 7, and 8 blackish brown, 6 somewhat lighter than the following. Bristles dark, also those on segment 9, the anals somewhat paler.

Head short and broad, broader than long, length from eyes, 173 μ; including interantennal projection, 200; width across eyes, 200; eyes, length laterally, 72 μ, the posterior ommata larger than the others, hind margin of eyes oblique, and therefore the inner margin of eyes obtuse-angular; distance of eyes, 100 to 105 μ; interantennal distance large, 28 μ; ocelli small, forming a very low triangle; interocellar bristles, 44 μ, pointed, 65 μ distant from each other; postoculars well developed, sharp, almost attached to hind margin of eyes, 68 μ; a few much smaller pairs on vertex and cheeks; the latter are distinctly rounded and converge posteriorly; mouth cone large, rounded at tip, la-

brum blunt, maxillary palpi, 32 (11) μ. Antennæ, length, 390 μ; measurements of joints: 32 to 36 (bristles 42, t. 30), 60 (35), 68 (32), 64 (32), 64 (32), 54 to 56 (28), 42 (24), 30 to 32 (13) μ; joint 1 converging towards tip, areola of joint 2 near apex, joint 3 transversely striated in basal half, with 2 slender, pointed sense cones, joint 4 with 2 + 2, 5 and 6 with $1 + 1^{+1}$ each; joint 6 with conspicuous basal stalk, 7 as well but stalk broad, 8 a little narrower at base than 7 at apex, conical, not constricted at base. Pronotum, length, 138 μ; width, 277; including coxæ, 295; bristles sharp, those on fore angles somewhat over 44 μ; inner anteromarginals, 32; posteroangulars, 68 to 72; inner posteromarginals, 48 to 52. Forelegs simple, fore tarsi unarmed in the female (male unknown). Pterothorax, width, 329 to 363 μ; wings present but not visible in the unique preparation (2 specimens), certainly not constricted in the middle, and moderately long; abdomen much broader than the thorax, bristles rather stout and towards apex of abdomen, dark, moderately long, those on segments 7 and 8, 116 and 95 μ; on segment 9, bristle 2, 104 to 108 μ; bristle 3 longer, over 120 μ; tube short and thick, sides convex in basal third, length, 148 to 160 μ; width at base, 88; across tip, 40 to 42; anals short, not more than 100 μ. Total body length, distended, 1.87 mm.

HOOKOTOO (island near Formosa), Makoo, June 5, 1930 (*S. Minowa*) (? beating).

It should be mentioned here that the typical *formosensis* has prothorax somewhat longer but tube shorter than have the specimens of *formosensis* var. *karnyi* var. nov. from Java, Tjibodas, 400 meters, 1923 (*Karny*), No. 32; Tjibodas, 1,400 meters, 1923 (*Fulmek*), No. 97, in which the tube has a length of 192 to 200 μ; width, 88 to 90 μ; and the prothorax is 120 to 130 μ, including coxæ, 303 μ; the wings of the Javanese form are infumated for their whole length, about 865 μ; their width is moderate, about 68 μ in the middle; double fringe, 8.

The genus *Neosmerinthothrips* Schmutz, generic type *N. fructuum* Schmutz, belongs to the Compsothripini and comes nearest to *Bolothrips* Priesner; it is characterized as follows:

Head short, strongly converging posteriorly; fore femora enlarged, at least in the male sex; fore tarsi with heavy tooth in the male, sometimes without teeth in the female; tube thick, broad at base, in some cases set with very small wartlets at sides; wings parallel-sided; eyes truncate behind, sometimes obliquely; bristles always pointed; in all species the femora are, except on outer margin, inclined to be paler than the tibiæ.

Habitus partly as in *Bolothrips*, partly as in *Eothrips*, but closely related only to the former genus. The following forms of this genus are known to me.

Key to the species of Neosmerinthothrips Schmutz.

1(4). Tube very thick at base, 1.6 to 1.7 times as long as broad, and at base (at least) 2.5 to 3 times (mostly 3.1 to 3.2) as broad as at apex.

2(3). Head larger and thicker, pronotum shorter; antennæ longer, third joint 72.80 μ; eyes broader than long, obliquely truncate behind. *N. fructuum* Schmutz.[3]

3(2). Head smaller, prothorax longer; antennæ shorter, third joint 60.30 μ; fore tarsi armed in both sexes; tube width across base (apex), in female, 112 to 116 (36) μ; in the male, 96 (32). *N. xylebori* sp. nov.

(Tegallega, near Tjibadak, West Java, 500 to 600 meters altitude, March 30, 1925, in channels of *Xyleborus coffeæ*, on coca (*Menzel*).

4(1). Tube at base 2.2 times (at the most) as broad as at apex, 1.9 to 2.3 times as long as broad at base; antennæ about as in *fructuum* but eyes somewhat longer than broad.

5(6). Tube, 192 to 208 (88 to 90) μ; pronotum, 120 to 130. *N. formosensis* var. *karnyi* var. nov.

6(5). Tube, 148 to 160 (88) μ; pronotum, 138..... *N. formosensis* sp. nov.

RHÆBOTHRIPS LATIVENTRIS Karny.

KARNY, Supplementa Entom. (1913) 129; Soc. Ent. Cech. 17 (1920) 42; Ark. f. Zool. 17A 2 (1924) 29, 50, pl. 4, figs. 35, 36.
MOULTON, Annot. Zool. Japon. 11 4 (1928) 337.

A series of this species (macropterous female, brachypterous male and female, and larvæ) was collected by H. Uchiyama, August 26, 1933, at Koronya, Ponape (Caroline Islands), on *Cassia occidentalis;* 1 macropterous male, Taihoku, Formosa, July 15, 1912, on *Gossypium* (*M. Maki*); 1 brachypterous male and 1 pupa, Tegallega, near Tjibadak, West Java, 500 to 600 m, March 18, 1925, in channels of *Xyleborus coffeæ*, on coca (*Menzel*); 1 macropterous male, Tjibodas, 1,500 m, August, 1921 (*Karny*), No. 348.

There is no important difference between the specimens from the various localities, but the macropterous males seem to have somewhat shorter antennæ (433 μ) than the brachypterous males (480 to 550 μ).

The female of this species has not been described.

Female.—Agrees with the male in coloration, shape of head and tube, antennæ, etc., but is quite different in the shape of the forelegs, which are normally built; that is, not bent as they

[3] I saw a female of this species in the collection of Dr. Ramakrishna Ayyar, No. 296 B(1).

should be according to the characteristics of the genus; this character, the strongly curved fore femora, is a male character only, and is also found in small males. The tarsal tooth is missing in the female; thus, the female of this genus is built exactly as *Bolothrips* Pr., only the antennæ are somewhat slenderer.

Head, length, 322 μ; including interantennal projection, 363; width across eyes, 225; behind eyes, 234; eyes, laterally, 87; ocelli moderately large, situated before the middle of the eyes; two well-developed interocellar bristles between the hind ocelli; postocular bristles longer than described by Karny, 120 μ and more, and therefore longer than an eye (also in the male). Fore femora, width, 120 μ. Antennæ, joint 3, 132 to 140 μ; joint 4, 124 to 128; joint 5, 104. Prothorax, length, 182 μ; width including coxæ, 415; two pairs of anteroangular bristles conspicuous, posteroangulars long, all pointed, the inner bristles 140 to 148 μ, longer than the outer; wings of the macropterous form with longitudinal streak, and 16 or 17 double fringe hairs; mesothorax 433 to 450 μ in both the macropterous and the brachypterous form. Tube length, 311 to 329 μ; evenly converging posteriorly, width across base, 120 μ; bristles on segment 9 of the abdomen, 242 to 260 μ.

The larvæ are very similar to those of *Bolothrips*, but antennal joint 3 is much longer, 135 to 140 μ, than in any known species of *Bolothrips*.

PLECTROTHRIPS CORTICINUS sp. nov.

Female.—Chestnut-brown, tibiæ somewhat lighter than the femora, yellowish brown; tips of fore femora and tarsi yellowish; bristles yellowish; joint 1 of antenna darkest, as dark as the head, the remainder yellow-brown, 3 a little paler than the others.

Head, length from eyes, 260 μ; total length, 290; width across middle of head (cheeks), 260; eyes varying in length, 78 to 100 μ, laterally; eyes obliquely truncate behind; cheeks evenly convex, their length behind eyes, 147 to 156 μ; hind ocelli far apart from each other, situated at anterior third of eyes at their inner margins, distance of corneæ, 96 μ; just behind the ocelli a pair of small bristles; postoculars long, 112 to 120 μ, pointed (as all the other bristles), situated in the middle of the cheeks, far distant (52 to 56 μ) from hind margin of eyes; surface of vertex smooth; mouth cone very short, as usual in this group, and broadly rounded; antennæ, length, 560 μ; measurements of joints: 40 (bristle 64), 76 (48), 88 (60), 80 (60), 72 (44), 68 (38), 62

(28), 74 (18) μ; joint 1 deeply inserted, sides converging towards apex; 2 with areola somewhat proximal from middle, 3 club-shaped, with 2 large but not very long sense cones which are rounded at tips, 4 with 1 + 2 sense cones, 5 and 6 with 1 + 1, 7 with 1 (lateral); joint 8 long, spindle-shaped. Chitinous central dorsal plate of pronotum 260 μ in length, width, 345; pronotum width, 398 (including coxæ 528); coxæ, as usual, very large, forelegs strongly enlarged, fore tibiæ without teeth, fore tarsi with sharp, curved tooth. Bristles around the central plate of the pronotum vestigial, those on hind angles long, 144 to 160 μ, hairlike; mesothorax width, 450 to 520 μ; wings reduced to small pads, invisible in the preparation; middle and hind legs, as usual, with two stout spurs; bristles on abdomen long, hairlike, bristle 1 on segment 9, over 240 μ; tube length, 264 μ; shape conical, abruptly constricted at apex, width, at base, 112 μ; at tip, 48; terminal hairs, about 240. Total body length, much distended, 2.7 to 3 mm.

Among the species with unarmed fore tibiæ, *P. corticinus* is distinguished from *P. atactus* Hood and *P. pallipes* Hood by the stouter body, and comes nearest to *P. collaris* Bagnall and *P. uncilumbis* (Karny); in *P. collaris* the prothorax is little broader than long and somewhat longer than the head; in *P. uncilumbis* the antennæ are entirely dark, and antennal joint 3 is somewhat shorter than 4.

FORMOSA, Taihoku, April 3, 1928, under bark of a decayed tree (*R. Takahashi*).

ELAPHROTHRIPS TAKAHASHII sp. nov.

Female.—Black, tarsi dark grayish brown, fore tibiæ (as the others) entirely black; spines at cheeks slightly shaded, posteroangular bristles of pronotum colorless, the remaining bristles of the body more or less shaded, those on segment 9 more faintly shaded; wings clear; antennal joints 1, 2, 7, and 8 uniformly blackish brown, 3 to 6 partly pale yellow, as follows: Joint 3 yellow with but end of club dark, 4 with club (apical two-fifths) dark, 5 with about apical half (or more), and 6 with apical two-thirds dark.

Head, length, from eyes, 614 μ; total, 744; width, across eyes, 260; behind eyes, 294; head projection long, as long as broad (136 : 136), very slightly widened anteriorly, front ocellus situated about in its middle, bordered by a pair of long, dark bristles; eyes, length laterally, 147 to 156 μ, outer margin of eyes parallel for about half of their lengths; three pairs of spines,

more or less faintly shaded, moderately stout, length of first, 44 to 48 μ; of third, 48 to 52; between them a few small spines; cheeks constricted behind the eyes, widened posteriorly, so that the head is wider behind than across eyes; there are two pairs of small postocular bristles, length, 60 to 65 μ; first pair 80 to 116 μ distant from eyes, thus placed irregularly; antennæ as usual in this genus, joint 3 with 2 long, hairlike sense cones, joint 4 with $2 + 2$, 5 with $1 + 1^{+1}$, 6 with $1 + 0^{+1}$, 7 with 1d; stalk of joints 3 to 5 slender, joint 8 somewhat constricted at base; measurements of joints: 60 (bristle 60, t. 48), 80 to 88 (48), 256 to 260 (bristle 26 to 28, t. 44), 222 to 224 (52), 174 to 180 (44), 132 to 144 (36), 86 to 92 (28), 80 (18) μ. Prothorax, length, 250 to 260 μ; width without coxæ, 415 to 433; fore angular and lateral bristles well developed, rounded at tips, length, about 72 to 80 μ; the inner anteromarginal smaller, 40 at most; posteroangulars, about 132, pale; as in other species, there is a small, lateral, toothlike prominence about the middle of the sides of the prothorax; coxal bristles about 76 μ; fore femora with 2 + 1 pale bristles at outer margin; fore tarsi unarmed (female). Pterothorax, width, 623 to 640 μ; wings, length, 2.9 mm, no dark streak indicated, 41 to 43 hairs duplicated; bristle 2 of abdominal segment 9, 450 μ. Tube, length, 588 to 606 μ; width at base, 138 (?); at apex, 69; tube slightly converging posteriorly, more strongly about the apical fourth; length of apical hairs, 345 μ. Male unknown.

LOOCHOO, Amami Ooshima, Gusuku, July 21, 1932 (*S. Minowa*).

This species, belonging to the group of forms having a long anteocular head projection—it is as long as broad in our species—has decidedly pale yellow base of antennal joints 4 to 6 and, therefore, comes close to *E. amœnus* Priesner and *E. fulmeki* Priesner; in *fulmeki*, however, the club of joints 3 and 4 is but indistinctly separated from the basal portion of the joint; therefore, the stalk is thicker, and this species is certainly not identical with the new one; *E. amœnus* has blackish spines on cheeks and fore femora, wings narrower, even somewhat narrowed in the middle, eyes convex, and only 25 fringe hairs duplicated.

LEEUWENIA PUGNATRIX sp. nov.

Female.—Blackish brown; the following parts pale yellow: All tarsi, fore tibiæ (except the extreme base which is faintly shaded at margins), distal half (or more) of the middle and

hind tibiæ, the antennæ from joint 3; joint 8, perhaps sometimes also apex of joint 7, faintly shaded. Wings clear or slightly yellowish.

Head, length, 311 μ; including interantennal projection, 337; width, across eyes, 190; behind eyes, 208 (216 μ in the type specimen, which has head somewhat pressed by the cover glass); a notch behind the eyes; lateral length of eyes, 100 to 105 μ; head surface somewhat rough, but distinctly netlike, sculptured only in front, near the eyes; postocular bristles very small, tender, length, not over 24 μ; hind ocelli situated before the middle of eyes; head indistinctly narrowed anteriorly, cheeks almost parallel; mouth cone short, broadly rounded, reaching only half across the prosternum. Antennæ, length, about 536 μ; slender; joint 1 nearly parallel-sided, 2 with four bristles around the areola, 3 slender, 4 less slender, and somewhat longer than 3, joint 8 not constricted at base, sense cones very thin and long, hairlike, reaching or surpassing the middle of the following joint, 1 cone on joint 3, 3 on joint 4, 2 + 1 (accessory) on joints 5 and 6, and 1 (dorsally) on joint 7; measurements of joints: 40 to 44 (42), 56 (32), 92 (28), 98 to 100 (34), 92 (34), 80 (34), 54 to 56 (24), 44 (14) μ. Pronotum short, length, 160 to 174 μ; width, 330; including coxæ, 380; surface with wrinkles emanating from median line, partly netlike; fore angle bristles yellow, blunt, length, 32 to 36 μ; the outer hind angle bristle of the same shape but longer, 92 to 100 μ, and situated on a little hump; no conspicuous bristles on coxæ; fore-legs somewhat reticulate or at least rugose, tarsi simple. Pterothorax, somewhat pressed, 476 μ wide; basal wing bristles short, inserted in a straight line, bristles 1 and 2, 24 to 32 μ; bristle 3, 40, yellow, blunt. Duplicated cilia wanting. Mesonotum finely and densely transversely striated, metanotum longitudinally striated basally, reticulated behind. The triangular basal plate of the first abdominal tergite reticulated; abdomen broadest at segment 2, 450 μ; length, 138; segment 5, width, 346 to 363 μ; length, 173; segment 7, width, 303 μ; length, 182; segment 8, width, 286 μ; length, 156; segment 9, width, 199 μ; length, 138; the latter strongly converging posteriorly; abdomen with thick, blunt, yellow bristles at the sides, which are somewhat shaded on segment 9, their length about 80 μ on segment 6, 70 μ on segment 9; tube very slender, length, 1.21 mm; basal width, 95 μ; apical width, 50 μ; about 13 times as long as broad at base; hairs at the sides of the tube tender, commencing not far from base, and terminating rather far from apex of tube, the

longest (52 μ) are about half as long as the width of the tube across middle, and these hairs are inserted at an angle of about 30° to 35°. Anal bristles, 190 to 208 μ; total body length, much distended, 3.67 mm.

FORMOSA, Hori, September, 1928, 1 female, on *Lithocarpus* (*R. Takahashi*).

This species belongs to the subgenus *Leeuwenia* sen. str., and is distinguished from *L. eugeniæ* Bagnall by the shape of the head, the shorter tube, and the much lighter coloration of the legs; from *L. coriacea* Bagnall by the color of the legs and by the conspicuous anterior lateral bristles of the pronotum; from *L. seriatrix* Karny by the shorter hairs of the tube, the less strongly transverse abdominal segments, and the shape of the head; from the remaining species it is easily separated by the much shorter tube hairs. From species of *Hoodiella* it is quite different by the much shorter head and tube.

292820——6

ACRIDIIDÆ AND TETTIGONIIDÆ FROM LUZON PHILIPPINE ISLANDS

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ELEVEN TEXT FIGURES

The present contribution is based on a collection of Orthoptera made by Mr. N. Ikonnikov, the well-known Russian authority in Palæarctic Acridiidæ, in the vicinity of Los Baños, Luzon, Philippine Islands, during the period from April 5 to May 25, 1917, and at present deposited in the Zoölogical Museum of Moscow University.

The collection contains forty-three species, of which thirty-three belong to the family Acrididæ and ten to the family Tettigoniidæ; three genera and ten species are new to science, but this number is not unexpected, since the fauna of the Philippine Islands seems to be extremely rich in Orthoptera. During recent years three well-known orthopterists—C. Willemse, M. Hebard, and H. Karny—have made known from this part of the Indo-Malayan Region many new genera and species of Orthoptera.

I wish to express my sincere thanks to Dr. C. Willemse for his advice on some doubtful points, and to Mr. A. Zhelakhovzev, Zoölogical Museum of Moscow University, who kindly submitted this collection to me for study.

The types of all new species are deposited in the Zoölogical Museum of Moscow University.

ACRIDIIDÆ

TETRIGINÆ

Genus CLEOSTRATUS Stål

CLEOSTRATUS MONOCERUS Stål.

Seven specimens. This genus contains only two species known from the Philippine Islands.

Genus HYMENOTES Westwood

HYMENOTES TRIANGULARIS Westwood.

Eleven specimens. Bolivar's *triangularis*, as shown by Kirby,[1] belongs to a quite distinct species named by him *H. bolivari*.

Genus MISYTHUS Stål

MISYTHUS ENSATRIX (Walker).

Two males.

MISYTHUS CRISTICORNIS (Walker).

One male and one female. Both species, known only from Luzon, were fully discussed by Hebard in his recent monograph of the genus *Misythus* (1932).

Genus DIOTARUS Stål

DIOTARUS IKONNIKOVI sp. nov. Text fig. 1.

LUZON, Laguna Province, Los Baños, April 15 to May 25, 1918, 7 males and 11 females (including the type) (*N. Ikonnikov*).

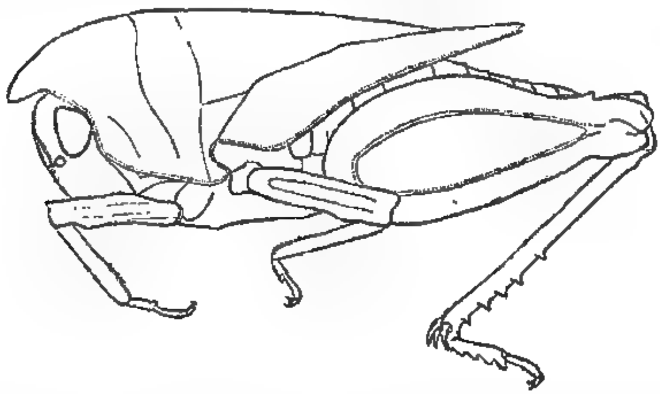

FIG. 1. *Diotarus ikonnikovi* sp. nov., the female type, lateral view; × 6.

Related to *D. pupus* Bolivar but differs strongly in the following features: Body larger; pronotum strongly tectiform in anterior three-fourths, with a sharp median keel; posterior part reaching the apex of abdomen and extending a little beyond the middle part of hind femora, strongly depressed and concave before apical extremity, with median keel gradually disappearing backwards and quite absent in the concave part; anterior half of disc without rugosities, punctured, posterior half with very distinct elevated keel-shaped rugosities some of which are more elevated and placed more or less obliquely to median keel; hind

[1] Catalogue 3: 4.

margin with obtuse angular excision; median keel seen in profile not strongly but regularly bowed in anterior half and practically straight in posterior half. Anterior and middle femora indistinctly undulated, with a feeble preapical lobule on the lower margin; hind femora with distinct and regular oblique wrinkles but without tubercles; hind tibiæ distinctly dilated apically, apex about half again as broad as the middle part of tibia; outer margin with five to seven, inner margin with five or six spines, placed, except for the apical spine, in a third quarter of tibia. Valvæ of the ovipositor long and slender, quite straight, except very slightly incurved apices.

Coloration variable, from light brownish to blackish brown, without black longitudinal stripes on the disc of pronotum, rarely with indistinct dark obliquely placed spots on the middle part of disc; lower outer surface of hind femora darkened; hind tibiæ blackish brown, with two very distinct light rings, one of which is placed on the apex of basal third and another in the basal part of apical half.

Length of body, male, 8 to 10.5 mm; female, 11.5 to 12.4; pronotum, male, 8.4 to 11.1; female, 10.6 to 12; hind femora, male, 5.7 to 7.1; female, 6.9 to 7.4.

This species may be easily distinguished from *D. pupus* by its larger size, shape of pronotum, and especially by the presence of five or six spines on the outer side of hind tibiæ (in *D. pupus* there are only two or three such spines). This last-mentioned feature is shown to be quite constant in a careful study of a series of eighteen specimens. The species is dedicated to its collector.

Genus EUGAVIALIDIUM Hancock

EUGAVIALIDIUM AURIVILLII (Bolivar).

One male and two females. Known only from the Philippine Islands. The species is very similar in its general habitus and the structure of hind tibiæ and tarsi to slender species of the genus *Scelimena* Serville (*S. producta* Serville and specially *S. india* Hancock) and differs from these species chiefly in the presence of very distinct lobes on anterior and middle femora.

Genus TEFRINDA Bolivar

TEFRINDA PALPATA (Stål).

Thirteen specimens. This genus (with a single species mentioned above) was described from the Philippine Islands. It has not been recorded from other parts of the Indo-Malayan

Region, although it is probably widely distributed in the Malay Archipelago, for some specimens of this genus are known to me from Lombok (in the Zoological Museum of the Academy of Sciences, Leningrad), that belong to a new and closely allied species.

Genus BOLOTETTIX Hancock

BOLOTETTIX PERMINUTUS (Bolivar).

Two males and two females. This species was described by Bolivar (1887) from Bulusan, Luzon, under the name *Criotettix perminutus* and included by Hancock (1907) without actual study of the species in the genus *Bolotettix*. Although the species differs from the genotype (*B. validispinus* Hancock, from Borneo) in the absence of a strong transversely produced spine on the lateral lobes of pronotum and in the presence of feebly developed lateral keels in prozona, it belongs to this genus as characterized by the very narrow vertex, cylindrical character of the anterior part of the pronotum, very small elytra (the latter distinctly narrower in the present species than the width of the middle femora), and the insertion of the antennæ barely below the eyes. Lateral keels in prozona very feeble, but distinct and markedly convergent backwards, as in representatives of the genus *Criotettix* Bolivar (Hebard); the disc of the pronotum bears two distinct, parallel, longitudinal carinæ placed between the humeral angles. The last-mentioned feature has not been described by Bolivar, and there is some doubt that these specimens belong to *B. perminutus;* it is possible that they represent a closely allied species.

BOLOTETTIX LUZONICUS sp. nov. Text fig. 2.

LUZON, Laguna Province, Los Baños, April 15, 1927, 1 male (*N. Ikonnikov*).

Similar in general habitus to *B. perminutus* Bolivar and closely related to it. Size small for the genus, form relatively stout. Eyes prominent, not strongly but distinctly elevated above the level of pronotum; interocular space much narrower than dorsal ocular width, about as broad at the middle as half the width of an eye, distinctly narrowing and a little ascendant anteriorly; vertex with distinct longitudinal keel on anterior half, apex with two, short, elevated, obliquely placed, lateral keels open in front; frontal costa, seen in profile, angulately elevated between antennal bases, upper part quite straight, lower part very obtusely excised a little below middle

ocellus; lateral ocelli placed a little below the middle of eyes. Pronotum truncate anteriorly, subulate posteriorly, not strongly but distinctly extending beyond the apex of hind femora; prozona with very feeble, indistinct, lateral keels, feebly convergent backwards; disc of pronotum depressed, practically flat, with dense and profound puncturation; median keel very low, obliterate before anterior margin of pronotum, feebly inflated but not elevated between transverse sulci; humeral angles obtusely angulate, distinctly carinate; supernumerary carinæ near humeral angles distinct; there are also two short, not strong, longitudinal carinæ on the disc between humeral angles. Lateral lobes with posterior angle strongly produced outward into practically transverse, long, conical spines. Elytra very small, narrow, narrowed apically with acutely rounded apex, the visible part about two and one-half times as long as broad. Wings fully developed, reaching the apex of the pronotal process. Anterior femora cylindrical, rather slender, the margins entire; middle femora somewhat depressed, with subundulate margins; hind femora relatively stout, with very distinct oblique rugosities, pregenicular tooth feeble; hind tibiæ regularly broadened to the apex, about twice as broad at the apex as the narrowest part in basal third; external margin with seven, inner margin with six spines; metatarsus scarcely longer than third tarsal joint; all three pulvilli subequal in length, acute but not pointed on the apex.

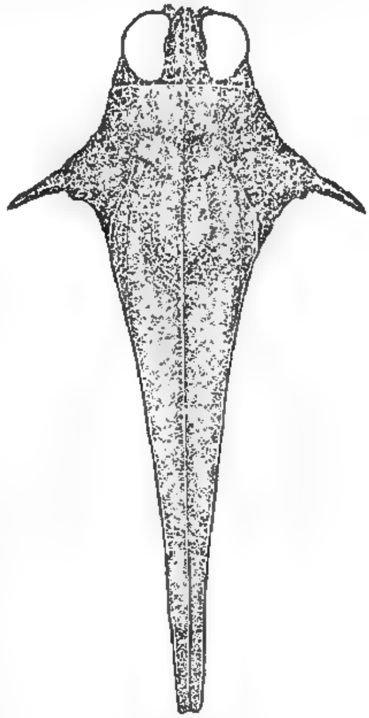

Fig. 2. *Boletettix luzonicus* sp. nov., head and pronotum of the type, dorsal view; × 10.

Coloration dark grayish brown. Elytra, the visible part of wings, lower outer part of hind femora blackened; anterior and middle legs with black rings; hind tibiæ blackish brown, with indistinct light ring at the base.

Length of body, 6.0 mm; pronotum, 7.8; hind femora, 4.5.

The type is unique.

This species is very distinct from *B. perminutus* in the less convergent lateral keel of the pronotal prozona, the more-dilated apex of the hind tibiæ, and chiefly in the presence of a long and sharp conical spine on the lateral lobes of the pronotum. Bruner [2] listed three new species of the genus *Loxilobus* Hancock and two new species of the genus *Boletettix* (of which four species are from Luzon and three even from Los Baños). These species have not yet been described and it is very probable that *B. luzonicus* sp. nov. is one of them.

Genus EUPARATETTIX Hancock

EUPARATETTIX SIMILIS Hancock?

Seven males and six females. This species was described by its author [3] from Borneo and the Philippines, but in the latter case without indication of an exact locality. The precise determination is very difficult without a comparison with typical series, although the description agrees well with the specimens in all principal features.

Genus PARATETTIX Bolivar

PARATETTIX (?) PALPATUS sp. nov. Text fig. 3.

LUZON, Laguna Province, Los Baños, May 15, 1917, 1 male; May 22, 1917, 1 male and 1 female (type) (*N. Ikonnikov*).

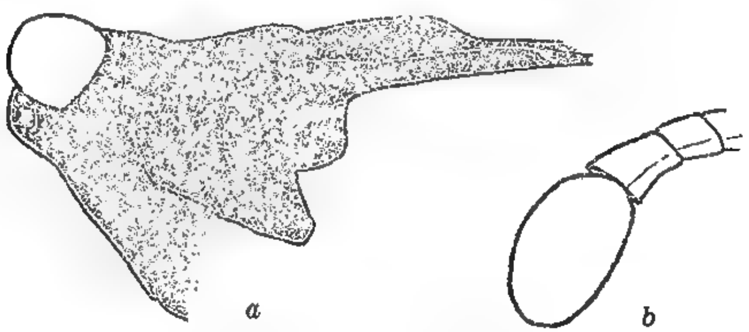

FIG. 3. *Paratettix* (?) *palpatus* sp. nov., a, head and pronotum of the type, lateral view; × 6; *b*, maxillary palpus, greatly enlarged.

Body elongated, slender. Eyes widely separated, globose, upper surface somewhat elevated above the level of vertex; vertex as broad as an eye, distinctly narrowed anteriorly, with a feeble longitudinal keel and two lateral, lobiform and obliquely placed

[2] Univ. Studies Lincoln 15 (1915) 244 and 249.
[3] Trans. Ent. Soc. London (1907) 238.

keels, which are distinctly convergent anteriorly; hind part of vertex with a small but distinct transverse keel-shaped elevation placed in the posterior quarter of interocular space. Frontal costa seen in profile strongly compressed-elevated between antennal bases; upper part between eyes quite vertical, obscured by eyes and not visible laterally, lower part distinctly obtusely excised at median ocellus; paired ocelli placed a little below the middle part of eyes. A line joining the ventral margins of eyes passes a little above the antennal base; antennæ very slender, twice as long as the anterior femora with very elongated joints. Maxillary palpi with apical joint depressed and dilated, half again as broad as the preceding joint.

Pronotum strongly elongated, truncate anteriorly, posteriorly subulate, reaching the apex of hind tibiæ; lateral keels in prozona not strong but distinct, feebly convergent backward; humeral angle keeled, supernumerary keels distinct, straight, reaching the posterior sulcus; transverse sulci very deep on the disc and lateral lobes; median keel distinct on its whole length, low, somewhat inflated between transverse sulci but not elevated; the disc flattened, densely and strongly punctured, interhumeral part on the middle somewhat elevated along the median keel and bordered with very distinct lateral longitudinal keels; interspace between these and median keel equal to the interspace between supernumerary and the same keels; posthumeral part of the disc, just behind apices of the longitudinal keels, distinctly depressed, with sparse, irregular, longitudinal callosities. Lateral lobes with posterior angle subvertical, roundly truncate at the apex; elytral and inferior sinuses rectangular.

Elytra relatively narrow, about three times as long as broad, apex not broadly rounded.

Anterior and middle femora very long, slender, carinæ entire; hind femora slender, with very distinct callous oblique elevations; posterior tibiæ scarcely dilated toward the apex, with six to eight outer, and five to seven inner spines, minutely serrulate between them; hind metatarsus equal in length to third joint.

Valvæ of the ovipositor long, slender, straight, strongly spinose.

Coloration dark grayish brown. Elytra with blackened lower margin; the visible part of wings black. Anterior and middle legs unicolorous, hind femora with lower outer part blackened; hind tibiæ blackish brown, with very indistinct light ring at the base.

Male.—Like the female, but smaller.

Length of body, male, 7.5 mm; female, 9; pronotum, male, 12 to 12.2; female, 14.2; hind femora, male, 4.8 to 5; female, 5.7.

The generic determination of this interesting species is somewhat doubtful as it is characterized by very peculiar structure of the head and maxillary palpi; in some respects it resembles the genus *Xistra* Bolivar, but the structure of the posterior angle of pronotum is typical for the group Acridiini. In all probability it represents an undescribed genus, but I hesitate to describe it as the group is in a state of confusion and a detailed revision of all genera is strongly necessary.

Bruner[4] recorded "*Platypalus* sp." from the Philippines; probably this is a misprint for "Platypalpus" (this genus was never described in Tetriginæ) and it is very probable that Bruner has had the same species.

PARATETTIX PLATYNOTUS sp. nov. Text fig. 4.

LUZON, Laguna Province, Los Baños, April 5, 1917, 1 female (type) and 1 male (*N. Ikonnikov*).

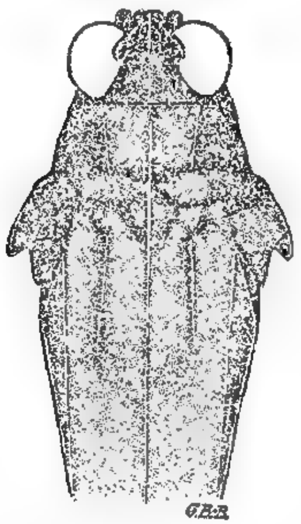

FIG. 4. *Paratettix platynotus* sp. nov., head and pronotum of the type, dorsal view; × 6.

Slender, elongated, size medium for the genus. Eyes scarcely elevated above the level of pronotum; vertex not ascendant forward, broad, slightly broader at the middle than an eye, somewhat narrowed anteriorly, median keel feeble but distinct, lateral keels in anterior part obliquely placed, convergent backward, forming with median keel a sharpened angle; frontal costa roundly produced between antennal bases, the supra-antennal part seen in profile not vertical, somewhat sloping, forming with vertex a rounded angle which is obscured by the eyes; the fork narrower than antennal socket; paired ocelli placed between the median points of eyes. Antennæ very thin (long ?); lower margin of antennal bases placed a little below lower margins of eyes.

[4] Op. cit. 249.

Pronotum strongly deplanate; the disc practically flat, finely tuberculate, with indistinct callosities; prozona somewhat broader than long, lateral keels very thin, feebly convergent backward; median keel very fine, not elevated, except the interval between the transverse sulci where it is very feebly inflated and indistinctly raised; anterior part of metazona from the hind transverse sulci with two very distinct, linear, straight carinæ, reaching a little beyond line connecting humeral angles; the latter distinctly keeled, obtusely angulate; supernumerary keels well developed, straight, beginning somewhat before shoulder angles; apical process reaching the apex of hind tibiæ, slender. Posterior angles of lateral lobes not reflexed outward, forming a sharpened and narrowly rounded angle.

Elytra oval; wings fully developed, reaching the apex of pronotal process.

Anterior and middle femora very slender, long, parallel-sided, about five times as long as broad, carinæ entire. Hind femora slender; hind metatarsus equal in length to third tarsal joint, the three pulvilli of the metatarsus equal in length, rectangular.

Coloration uniformly grayish brown.

Length of body, male, 6.7 mm; female, 9.3; pronotum, male, 11.6; female, 12.7; hind femora, male, 4.9; female, 5.3.

This well-characterized species shows distinct affinity to the Bornean *P. angulobus* Hancock [5] in the depressed pronotum bearing two abbreviated carinæ between humeral angles, in the quite similar structure of hind tarsi, and in some other features; but the new species is well separated from *P. angulobus* by the broader vertex, strongly narrowed anteriorly; by the distinctly bicarinate shoulders, not reflexed outward; by the posterior angle of the lateral lobes; and by some less-important features.

PARATETTIX sp. nov.?

Two males. An extremely graceful species; densely pilose lower surface of body very narrow; long pronotum with median keel sharpened and, seen in profile, practically straight, with spiculate pulvilli on hind tarsus. Probably a new species, but I hesitate to describe it without a comparison with others belonging to the same group of this genus.

[5] Trans. Ent. Soc. London (1907) 236.

Genus HEDOTETTIX Bolivar

HEDOTETTIX GUIBELONDOI Bolivar?

Four males and six females. In its general habitus, structure of pronotum and head, this species resembles strongly *H. gracilis* De Haan, but differs from the latter in the less-elevated median keel of pronotum and in the longer third pulvillus of the hind metatarsus; in this respect it agrees with *H. guibelondoi* Bolivar, described from the Philippines (Sibul), on the female sex alone and then recorded by Bruner [6] from Los Baños. The male sex, as in *H. gracilis,* is characterized by short and broad median femora.

HEDOTETTIX sp.?

One male. The exact determination of this single specimen is impossible without a comparison with other members of the genus.

EUMASTACINÆ

Genus MNESICLES Stål

MNESICLES sp. (aff. FURCATUS Saussure).

One female. This is probably a new species; it resembles *M. furcatus* Saussure, from New Guinea, in the structure of the subgenital plate.

I hesitate to describe a new species on a single female specimen without comparison with true *M. furcatus.*

MNESICLES CRASSIPES Karsch?

Two females. The female sex of *M. crassipes* is unknown and therefore an exact determination of these specimens is impossible. In C. Bolivar's key of the species of the genus *Mnesicles* [7] it runs to *M. novæguineæ* Bolivar, but according to Doctor Willemse, who studied one female specimen, it is certainly not identical with this species.

Female.—Fastigium of the vertex distinctly produced, subparallel, about twice as long as the interocular space, seen in profile distinctly projecting before dorsoanterior margin of eye, upper surface very feebly sloping backward, practically horizontal; face somewhat rugged but without distinct rugosities. Pronotum with truncate anterior margin and roundly triangular hind margin, prozona subcylindrical, equal in length to metazona; seen in profile the dorsal surface of the pronotum is

[6] Op. cit. 249.

[7] Bol. Soc. Esp. Hist. Nat. 31 (1931) 292.

distinctly concave; median keel well developed, especially in metazona, interrupted between transverse sulci. Elytra narrow, practically parallel-sided, with very feebly dilated apical extremity, reaching the base of the genicular part of hind femora. Anterior femora broad, without conical projection in the basal part; hind femora thick, about three times as broad as the elytra; dorsomedian and dorsoexternal keels with relatively sparse denticulation; three lower keels unarmed. Hind tibiæ distinctly sinuated, with twenty-one or twenty-two spines on the outer, and fifteen spines on the inner side. Subgenital plate with profound, narrowly triangular excision on hind margin and narrowly rounded lobes.

General coloration brownish gray, with dark and pale spots. Face dirty pale, with brownish gray spots; antennæ grayish in basal half and blackened in apical half. Elytra brownish gray with a narrow preapical pale band; wings infumated. Hind femora with blackish brown fasciæ and spots; hind tibiæ blackish brown, with pale fasciæ and spots.

Length of body, 22 mm; pronotum, 3.9; elytra, 12.3; hind femora, 12.7.

Genus ERIANTHUS Stål

ERIANTHUS ERECTUS Karsch.

Thirteen males and seven females. Doctor Willemse has kindly compared my specimens with typical *E. erectus* determined by C. Bolivar.

ACRIDIINÆ

Genus AIOLOPUS Fieber

AIOLOPUS TAMULUS (Fabricius).

Many specimens. A widely distributed species previously known from the Philippine Islands.

Genus EOSCYLLINA Rehn

Eoscyllina REHN, Bull. Am. Mus. Nat. Hist. 26 (1909) 186–188 (genotype, *Eoscyllina inexpectata* Rehn, from Sumatra).

Bakerella BOLIVAR, Trab. Mus. Nac. Cienc. Nat., Zool. N 20 (1914) 70–71 (genotype, *Bakerella luzonica* Bolivar, from the Philippine Islands) (syn. nov.).

Bolivar did not mention the most peculiar feature of the genus *Bakerella* (the strongly unequal inner calcaria of the hind tibia) and therefore he incorrectly included this genus in the group Ochrilidiæ. The genus is unquestionably a member of

the group Scyllinæ (= Prosthetophymæ Bolivar) as characterized by strongly unequal inner calcaria of the hind tibiæ. Moreover, a careful comparison of the topotypic specimens of Bolivar's *Bakerella luzonica* (fully described by me below) with very good description and figures of Rehn's *Eoscyllina inexpectata* convinced me of the identity of the two genera; both genotypes are extremely similar, practically in all essential features, and show very close affinity. Dr. C. Willemse, who studied my specimens, has advanced the same opinion with regard to the synonymy of these genera.

EOSCYLLINA LUZONICA (Bolivar). **Text fig. 5.**

Bakerella luzonica BOLIVAR, Trab. Mus. Nac. Cienc. Nat., Zool. N 20 (1914) 71 (♂, ♀; Los Baños, Luzon, Philippine Islands).

LUZON, Laguna Province, Los Baños, April 15 to May 25, 1917, 19 males and 16 females (*N. Ikonnikov*).

Female.—Allied to the type species *E. inexpectata* Rehn, from Sumatra, but differing somewhat in the shorter elytra and in other features. Form elongate, slender. Head with interocular space distinctly narrower than the fastigium and a little broader than the maximum width of the frontal costa; fastigium of vertex rectangular on the apex, somewhat shorter than broad, with very distinct transverse bow-shaped impression, slightly sloping, practically horizontal; foveolæ of vertex well marked, subrectangular, with sharp margins, a little less than twice as long as broad, subvertical and, therefore, not completely visible from above; occiput with a feeble but distinct median carina throughout, reaching anteriorly the middle of the interocular space, and with two very indistinct supplementary carinæ, moderately divergent backward, surface between carinæ with more or less distinct transverse rugosities; face strongly reclinate, slightly convex, forming with the fastigium a rather narrowly rounded angle of about 45°; frontal costa strongly narrowed to the fastigium, scarcely constricted near the middle ocellus and subparallel below it, with a very distinct median carina between middle ocellus and upper margin of the costa; lower part not impressed, with a dense and coarse puncturation; supplementary facial carinæ relatively sharp, very regularly incurved; there

FIG. 5. *Eoscyllina luzonica* Bol., apex of hind tibia of female, greatly enlarged.

is also a pair of irregular and abbreviate carinæ placed below antennal socket along inner side of the supplementary carinæ; eyes acute above, anterior margin almost straight, about two and one-half times as long as the infraocular portion of the genæ; antennæ scarcely longer than the head and pronotum.

Pronotum with lateral keels well developed, practically straight, subparallel in the prozona and more distinctly divergent in the metazona; there are also two less distinct, quite parallel, supplementary, longitudinal carinæ; transverse sulcus a little before the middle of the pronotum; median keel very distinct but low; hind margin obtusely angulate, with the apex rounded, anterior margin subtruncate. Lateral lobes vertical, their vertical depth a little greater than dorsal length, anterior half of the ventral margin obliquely truncate.

Elytra extending beyond the apex of hind femora for a distance equal to half the pronotum, relatively narrow, as broad as the maximum width of hind femora, apex narrowly rounded; intercalary vein in discoidal field irregular but almost completely developed. Wings relatively narrow, subtriangular, apices of two first lobes well separated.

Hind femora reaching well beyond the apex of the abdomen; hind tibiæ with dense and long hairs, distinctly shorter than the femora, inner side with twelve or thirteen, outer side with eleven or twelve spines; internal calcaria distinctly unequal, strongly incurved apically.

Valvæ of the ovipositor relatively short and thick; dorsal surface of the upper pair strongly bowed downwards; lower pair without teeth on the outer margin, but obtusely excised.

Male.—Smaller and much slenderer. Head with very feeble and indistinct longitudinal carinæ on the occiput; additional pair of the suplementary facial carinæ very short and sometimes almost indistinct; fastigium of vertex forming an angle a little less than 90°; antennæ practically half again as long as the head and pronotum.

Supplementary longitudinal carinæ of the pronotum very feeble or indistinct. Elytra with feebly broadened scapular area, which is scarcely broader than discoidal area; scapular area reaching the base of the apical third of elytra; apical third parallel-sided except for a short apical distance; discoidal area with an irregular, sometimes broken and abbreviate false vein.

Hind tibiæ with nine to eleven spines on the outer side and eleven or twelve spines on the inner side.

Subgenital plate densely pilose, relatively short, broadly conical, apex moderately acute; anal plate triangular, a little longer than broad at the base, with a feeble, median, longitudinal impression; cerci narrowly conical, acute at the apex, reaching the apex of the anal plate.

General coloration very variable, from pale yellowish to uniformly coal black, with various intermediate forms. Antennæ black or in pale yellowish specimens with pale brownish basal half of the upper surface and dark brownish lower surface. Elytra unicolorous or with indistinct dark spots, especially in discoidal area. Wings pellucid; apices of the first and second lobes infumate. Hind femora uniformly pale yellow, with blackened upper part of genicular area, or in dark specimens with several small black spots, especially along upper and lower outer keel, or sometimes completely black; hind tibiæ dirty yellowish, reddish brown, or, in the pale yellowish specimens, dirty reddish; spines black-tipped. Abdomen pale yellowish.

Length of body, male, 15.5 to 17.5 mm; female, 20 to 23; pronotum, male, 2.9 to 3.1; female, 3.5 to 4; elytra, male, 15.1 to 16.2; female, 17.3 to 19; hind femora, male, 10.3 to 11.1; female, 11.6 to 13.1.

This interesting species differs from the genotype in somewhat shorter elytra, in the presence of supplementary carinæ on the occiput and pronotum, and in densely pilose hind tibiæ.

I was greatly surprised to see a long series of specimens belonging to the genus *Eoscyllina* previously known from the single female type specimen from Sumatra, and at first I was inclined to describe a new species of this genus; but a detailed comparison of my series with Bolivar's *Bakerella luzonica* showed that my species is identical with the latter.

The group Scyllinæ (= Prosthetophymæ), fully represented in the American fauna, includes but few Indo-Malayan genera and species, and the discovery of an additional species in the Philippine Islands is very interesting.

ŒDIPODINÆ

Genus TRILOPHIDIA Stål

TRILOPHIDIA ANNULATA (Thunberg).

Twelve males. The structure of the pronotum as in typical *annulata*, but specimens differ from this species in somewhat smaller size; therefore, they were determined previously by me

as *T. cristella* Stål, but Doctor Willemse has identified them as *T. annulata*.

The dimensions of the series are as follows: Length of body, male, 12.5 to 15.1 mm; female, 17.2 to 18.5; pronotum, male, 2.9 to 3.4; female, 3.5 to 4; elytra, male, 13.9 to 16.0; female, 16.8 to 18; hind femora, male, 8 to 9.5; female, 9.3 to 10.2.

Genus GASTRIMARGUS Saussure

GASTRIMARGUS MARMORATUS (Thunberg).

Nine males and six females. A widely distributed species. Specimens belong to var. *transversus* Thunberg.

Genus HETEROPTERNIS Stål

HETEROPTERNIS RESPONDENS (Walker).

Ten males and eight females. The coloration in the present series varies from almost coal black to dark yellowish brown.

PYRGOMORPHINÆ

Genus ATRACTOMORPHA Saussure

ATRACTOMORPHA PSITTACINA (De Haan).

Twenty-five males and six females. A widely distributed Indo-Malayan species previously recorded from the Philippine Islands.

CATANTOPINÆ

Genus IKONNIKOVIA novum

A member of the group Euthymiæ; not closely related to *Euthymia* and its nearest allies, but resembling somewhat in the structure of the pronotum the Central American group *Mezentia* Stål.

Body short and thick. Antennæ filiform, long, extending beyond basal part of hind femora. Head very short, not broader than pronotum, face quite vertical, coarsely punctured; frontal ridge seen in profile quite straight, not projecting between antennal bases, without a sulcus, with very coarse puncturation; lateral margins subparallel, except a slightly widened part just below antennal base, subobliterated below and scarcely reaching the lower margin of front; median ocellus feebly, supplementary facial carinæ well marked, strongly divergent downwards, practically straight; fastigium of vertex short, strongly sloping, almost hexagonal, margins obtuse, practically as broad as long, its surface slightly concave, with a distinct transverse impres-

sion; forming with the frontal costa a very obtuse and rounded, practically indistinct angle; interocular space half again as broad as the frontal costa; eyes not strongly prominent sideways, oval, a little more than twice as long as the infraocular distance of genæ.

Pronotum twice as long as the head, subparallel-sided, without any trace of lateral keels and with a very faint indication of a median keel; all three sulci well indicated on the disc and lateral lobes, third sulcus placed in hind part of the posterior third quarter, second sulcus placed in the middle of the pronotum; anterior margin subtruncate; metazona somewhat elevated, with a well-marked but small, roundly obtuse tubercle, projecting backward, but not extending beyond the straight hind margin of the pronotum. Lateral lobes vertical, without a distinct upper border, strongly narrowed downward, with almost straight anterior margin and oblique hind margin, without indication of humeral angles; lower part of lateral lobes roundly triangular. Prosternal tubercle strongly flattened, distinctly widened apically, with the apex truncate. Mesosternal lobes somewhat broader than long, with broadly rounded inner margins, interspace between them slightly broader than long; metasternal lobes not broadly separated.

Elytra and wings strongly abbreviated, the former considerably shorter than pronotum, broader than long, rhomboidal, scarcely touching each other by their inner posterior angles; the surface of elytra covered with dense reticulation of veins, longitudinal veins indistinct; wings of the same length as the elytra, a little projecting in a small lobule above the upper hind angle and behind posterior lower angle of elytra.

Hind femora relatively slender, strongly extending beyond the apex of the abdomen, margins entire, the outer upper and lower area very narrow, knee lobes subrectangular. Hind tibiæ slightly sinuate, with nine spines on both sides, outer apical spine very distinct; hind tarsi practically reaching the middle of hind tibiæ, third joint equal in length to two preceding taken together.

Abdomen with tympanum well developed. Supra-anal plate of female triangular, not longer than broad, without keels or impressions, apex rectangular; cerci of female very short, conical; valvæ of the ovipositor relatively short, upper pair strongly concave above, with roundly incurved and acute apex; lower pair with very narrow, slightly incurved apices, without outer tooth.

The whole surface of the body covered with hairs, which are longer and dense on the hind margin of the pronotum and metazonal tubercle, on elytra, and on hind tibiæ.

Genotype.—*Ikonnikovia philippina* sp. nov.

This peculiar genus is characterized by a number of important features and resembles somewhat in the structure of the pronotum the genus *Mezentia* Stål, which, according to descriptions by Stål (1878) and Hebard (1932), is more or less similar in the structure of the metazona of pronotum, but with a more-developed and elevated tubercle. From a single brachypterous Indo-Malayan member of the group (*Perakia* Ramme) it strongly differs in the structure of the pronotum, the form of the elytra, and many other features.

IKONNIKOVIA PHILIPPINA sp. nov. Text fig. 6.

LUZON, Laguna Province, Los Baños, May 15, 1917, 1 female (*N. Ikonnikov*).

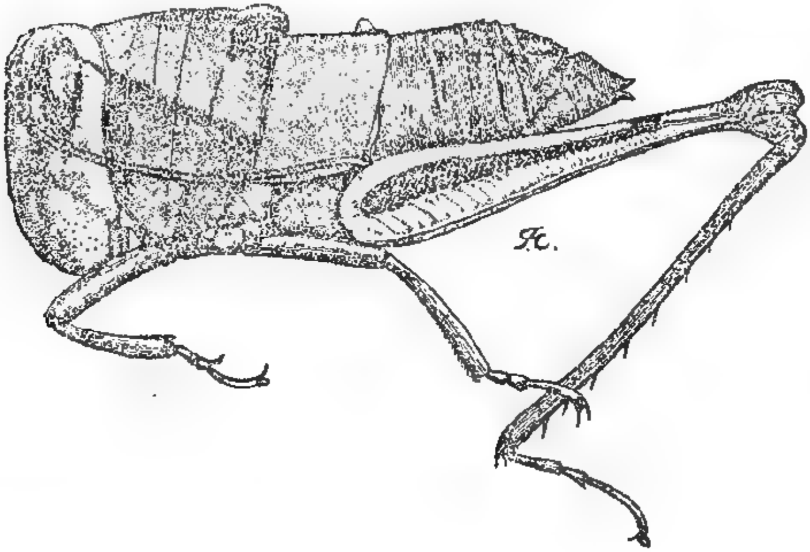

FIG. 6. *Ikonnikovia philippina* gen. et sp. nov., the female type, lateral view; × 4.

Female.—General coloration brownish yellow, with black stripe. Front dark brownish; antennæ blackish except pale yellow basal and four apical joints; occiput with two lateral postocular black stripes and with a short black median stripe just before the pronotum. Pronotum and lateral lobes dirty yellow with a broad, oblique, pale yellow stripe on lateral margins of

the disc, bordered below with very sharp, narrow, and oblique black stripe; disc of the metazona black, except brownish yellow tubercle. Elytra uniformly yellow. Abdomen and thorax uniformly brownish yellow, valvæ of the ovipositor olivaceous. Hind femora yellow, with very sharp black longitudinal stripe narrowed apically but tipped by a black transverse fascia on the upper and inner side of the basal part of the apical third of femora; inner side pale yellow except the above-mentioned black fascia; lower side reddish; knee part reddish brown. Hind tibiæ and tarsi, anterior and middle legs, greenish olivaceous.

Length of body (abdomen somewhat constricted), 19.5 mm; antennæ, 14; pronotum, 5.9; elytra, 3; hind femora, 16.

The type is unique.

Genus OXYA Serville

OXYA INTRICATA Stål.

Many specimens. A widely distributed Indo-Malayan species.

Genus PSEUDOGERUNDA novum

A brachypterous member of the group Oxyæ with hind tibiæ lacking the outer apical spine. Body slender, finely rugose. Antennæ filiform, long in male, extending behind the base of hind femora for a distance subequal to maximum width of the latter, in female somewhat shorter than the head and pronotum together. Head equal in length to pronotum, with strongly reclinate and coarsely punctured face; frontal ridge seen in profile quite straight, not projecting between the antennæ; its keels straight, feebly divergent downwards; sulcus distinct and relatively deep on the whole length of the ridge. Supplementary facial carinæ distinct, sharp, practically straight. Fastigium of vertex not strongly but distinctly sloping, not separated from the frontal ridge by a transverse keel, forming with the frontal ridge an acute but rounded angle, parallel-sided in basal part and widened forwards, anterior margin broadly rounded; the surface somewhat impressed on the middle and with a fine but distinct median carinula in anterior part; occiput feebly convex, somewhat rugose laterally, but without median carinula; interocular space about as broad as the lower part of the frontal ridge; eyes oval, relatively broad, prominent sideways, about two and one-half times as long as the subocular sulcus.

Pronotum cylindrical, finely rugose, without lateral keels; median keel subobsolete, present only in anterior fourth part of the prozona and in the metazona; anterior margin subtruncate; posterior margin triangularly excised in the middle; transverse sulci

fine but distinct; first sulcus developed on the disc only; two other sulci both on the disc and on the lobes; third sulcus placed far behind the middle; lateral lobes longer than high, vertical, the lower margin ascendant from its middle to the anterior angle, which is very obtuse, rounded; posterior angle rounded, obtuse-angulate; posterior margin feebly excised. Prosternal tubercle slender, conical, acute but not pointed on the apex, quite straight. Mesosternal lobes strongly transverse, their interspace very narrow, in male about twice, in female half again as long as broad, metasternal lobes contiguous (male) or subcontiguous (female) in the posterior part.

Elytra rudimentary, lateral, squamiform, very narrow; reaching the posterior margin of the second abdominal tergite, upper (hind) margin straight, lower (anterior) subparallel to the upper, bow-shaped, incurved; apex rounded; wings absent. Tympanum membranaceous.

Anterior and middle femora thickened; hind femora relatively thick in basal part, with very sparse long hairs; all the keels smooth; knee lobes angulate but not pointed on the apex, inner lobe acute, outer lobe nearly rectangular. Hind tibiæ not expanded apically, straight, margins smooth, with seven or eight spines on the outer, and nine or ten on the inner side, densely pilose, especially in the male; outer apical spine absent; hind tarsi somewhat shorter than half the length of hind tibiæ, metatarsus about twice as long as the second joint and subequal in length to the third joint; calcaria between claws large.

Abdomen very slender, especially in the male, with median longitudinal keel, rugosely punctured above; five to seven sternites densely pilose, especially in the female. Supra-anal plate short, transverse, with very distinct, especially in the male, longitudinal sulcus, hind margin truncate (female) or subexcised on the middle (male); subgenital plate in male short, obtusely conical, in female triangular, acute on the apex; cerci narrowly conical, in male considerably, in female a little, longer than supra-anal plate; valvæ of the ovipositor relatively short, thickened in basal part, upper pair roundly excised above, with the apex acute and roundly incurved; lower pair with a strong, rounded excision in apical half and with a narrow and feebly incurved apical part; margins without distinct denticles.

Genotype.—*Pseudogerunda willemsei* sp. nov.

Although this genus is characterized by the absence of the external apical spine of the hind tibiæ, it unquestionably belongs to the group Oxyæ as it has all the features peculiar to this group.

It resembles strongly the genus *Gerunda* Bolivar (known also from the Philippine Islands) in many features and was provisionally determined by me as a member of this genus, but *Gerunda* is characterized by the presence of the external apical spine on the hind femora. Dr. C. Willemse, who studied my specimens, has considered that they belong to a new genus and species. In Bolivar's key [8] the new genus runs to *Gerista* Bolivar but is not closely allied to it.

PSEUDOGERUNDA WILLEMSEI sp. nov. Text fig. 7.

LUZON, Laguna Province, Los Baños, May 15 to 22, 1917, 3 males (including the type) and 1 female (*N. Ikonnikov*).

Male.—Size relatively small for the group. Body densely pilose, especially the lower surface and the legs. General coloration dirty olive-green. Antennæ uniformly blackish brown; face between supplementary lateral carinæ dark marmoraceous, postocular stripe very broad, blackish brown or black, bordered on its lower margin by a narrow pale yellowish stripe reaching the middle of anterior margin of eye; dorsal surface of the head dirty yellowish, sometimes with a dark longitudinal stripe. Disc of pronotum of the same color as the dorsal surface of the head; lateral lobes blackish brown or black, with a relatively broad, pale yellowish, longitudinal stripe a little above the lower margin of lobes. Elytra uniformly blackish brown. Metapleura black, with a pale spot. Abdomen dirty yellowish, with an indistinct dark lateral stripe, apex reddish yellow. Legs olivaceous-green; lower surface of hind femora pale yellow, genicular arch blackened; hind tibiæ dirty red, with somewhat darkened basal half; two basal joints of hind tarsi reddish, apical joint olivaceous.

FIG. 7. *Pseudogerunda willemsei* gen. et sp. nov., head, pronotum, and elytra of the type, lateral view; × 7.5.

Female.—Considerably larger and more robust. Coloration as in the male, but lateral longitudinal stripes on the abdomen broader and more distinct.

Length of body, male, 17.2 to 17.6 mm; female, 23.5; pronotum, male, 3.7 to 3.8; female, 4.6; elytra, male, 2.5 to 3; female, 3.8; hind femora, male, 11.2 to 11.8; female, 14.7.

This new species is dedicated to Dr. C. Willemse, the well-known authority on the Indo-Malayan Acridiidæ.

[8] Trab. Mus. Nac. Cienc. Nat., Madrid N 34 (1918) 6–13.

Genus PARRACILIA Willemse

PARRACILIA LUZONICA Willemse.

One female and one larva (female). This genus and this species were described by Willemse from Baguio, Luzon, on a single female specimen. Specimens from Los Baños agree well with the original description;[9] the adult female was also compared by Doctor Willemse with a type of this species.

Genus BINALUACRIS Willemse

BINALUACRIS POLYCHROMA sp. nov. Text fig. 8.

LUZON, Laguna Province, Los Baños, May 15 to 22, 1917, 2 males (*N. Ikonnikov*).

Male.—Size small, body slender. Antennæ reaching the base of hind femora. The structure of the head and pronotum as in the genotype, *B. viridis* Willemse. Elytra lateral, scalelike, scarcely widened to the apex of the second third, rounded on the apex, reaching the base of the second abdominal segment. Abdomen slender, carinate above. Anterior and median femora thickened, about twice as broad as the respective tibiæ, with sparse and short hairs, hind femora long and relatively thick, extending well beyond the apex of abdomen, sparsely pilose, outer genicular lobes rounded, inner lobes practically rectangular; hind tibiæ very feebly S-shaped incurved, practically straight, with dense and long hairs, outer side with seven or eight, inner side with nine spines, outer apical spine absent. External genitalia as in the genotype.

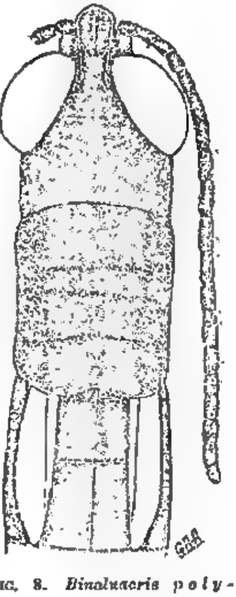

FIG. 8. *Binaluacris polychroma* sp. nov., head, pronotum, and elytra of the type, dorsal view; × 7.5.

General coloration green. Antennæ dark blue except the light blue basal part and whitish apical joint. Head and pronotum uniformly green, without stripes. Basal part of abdomen and elytra of the same color as the head and pronotum, apical part red; cerci brownish black, supra-anal plate red. Sternum and the basal part of abdomen yellowish green. Anterior and median femora olivaceous-green, anterior

[9] Natuurhist. Maandbl. (1933) No. 10.

and median tibiæ bluish. External and inner sides of hind femora orange-red in the basal third, knee part red, the intermediate part green; basal half of the lower sides orange-red, the remaining part bluish green; hind tibiæ dark blue, spines dark blue, with blackish brown tips; tarsi olivaceous-green.

Length of body, 16.9 mm; pronotum, 3.6 to 3.7; elytra, 2.8 to 2.9; hind femora, 10.8.

This handsome species is very similar in its morphological features to the genotype, *B. viridis* Willemse, recently described from Palawan Island. The new species is easily separated from *B. viridis* by its smaller size, shorter antennæ, and very striking coloration, specially of the antennæ, hind femora, and hind tibiæ.

Doctor Willemse has compared the new species with a paratypical specimen of his *B. viridis* and fully agrees with my determination of this insect.

Genus TONISTA Bolivar

TONISTA BICOLOR (De Haan).

Five males. This species was previously known from Japan, Java, Bali, and Sumatra; and, therefore, its occurrence in the Philippine Islands is quite natural.

The specimens agree well with Willemse's redescription and figures of this species.[10]

Genus BIBRACTE Stål

BIBRACTE BIMACULATA sp. nov. Text fig. 9.

LUZON, Laguna Province, Los Baños, May 5 to 15, 1917, 4 males (including the type) and 8 females (*N. Ikonnikov*).

Male.—Body robust, size relatively large. Head with distinctly reclinate and practically smooth face; frontal costa slightly widened between antennal bases, distinctly narrowed to the fastigium, and equally broad below median ocellus; margins feebly raised, the surface between them feebly punctured, not rugose; eyes moderately prominent sideways, nearly twice as long as the subocular part of the genæ; interocular distance a little broader than the maximum width of the frontal ridge; supplementary facial carinæ well indicated, subparallel. Antennæ reaching a little beyond the posterior margin of pronotum.

Pronotum rugosely punctured, strongly tectiform, median keel strong, sharp, not very deeply interrupted by three transverse sulci, the third sulcus placed near the base of the second third;

[10] Zool. Mededeel. 11 (1928) 2–3, pl. 1, figs. 1–3.

seen in profile the keel is somewhat elevated in the anterior two-thirds, slightly concave behind the third sulcus and feebly elevated at the hind margin; the latter is very obtusely angulate, practically straight, with a feeble excision on the middle. Lateral lobes quite vertical in the lower part, with very distinct, elongated, oblique inflation in prozona placed between the hind transverse sulcus and the middle part of the anterior margin. Prosternal tubercle short, slender, sharply conical. Mesosternal interspace a little longer than broad.

Elytra strongly abbreviate, lateral, scalelike, somewhat shorter than pronotum, scarcely reaching the middle of the second abdominal tergite, widened apically and regularly rounded on the apex; postradial area a little broader than the preradial. Wings absent.

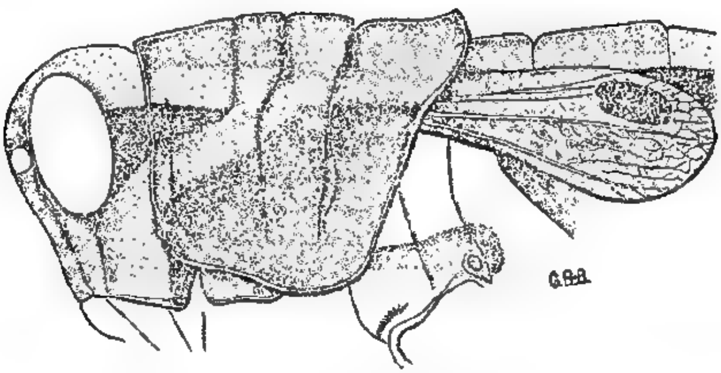

FIG. 9. *Bibracte bimaculata* sp. nov., head, pronotum, and elytra of the type, lateral view; × 10.

Abdomen with a very distinct, longitudinal, supra-anal plate, triangular, elongated, apex acute; basal half with a very distinct longitudinal furrow bordered with acute keels; cerci narrowly conical, relatively long, covered with relatively dense and long hairs, apex acute, subgenital plate short, obtusely conical, apex in profile rectangular. Hind femora relatively long, rather thick; hind tibiæ with seven or eight outer, and nine or ten inner spines; inner spines a little longer than the outer.

Female.—Like the male, but considerably larger and more robust. Antennæ extending beyond third transverse sulcus, but not reaching the hind margin of the pronotum. Mesosternal interspace scarcely broader than long. Supra-anal plate with less distinct longitudinal furrow in the basal half; apex rounded angulate, with very feeble and obtuse median excision; cerci short,

not reaching the apex of the supra-anal plate. Valvæ of the ovipositor densely pilose, relatively slender and long, upper pair somewhat longer than the lower, with feebly incurved apex, lower pair very narrow, with strongly narrowed and feebly incurved apical half.

General coloration brown or greenish brown, with black and pale stripes and spots, especially in the male sex. Antennæ blackish brown, except the lower surface of the basal half. Head pale or brownish, in male with a blackish postocular stripe. Pronotum with brownish disc and pale yellow postocular triangular spot in the prozona, including a dark triangular stripe, often indistinct in the female. Lateral lobes below the oblique inflation shining black (male) or dark brownish (female).

Elytra brownish, with very distinct preapical shining black spot, placed in the postradial field; rarely this spot is very feebly developed. Pleuræ pale yellow or brownish. Abdomen pale or pale brownish, with a broad, lateral, longitudinal, black stripe, often less indicated in female; lower surface dirty pale. Anterior and median legs with blackish and pale spots and fasciæ; hind femora in male with blackened external surface, including two pale yellow, somewhat oblique, spots not reaching the upper external keel; these spots are less indicated in female; upper surface dirty pale or brownish, with blackened spines on the upper keel; inner surface black, with pale median and preapical fasciæ, lower outer surface black, lower inner surface red; knee part not darkened, pale reddish or dirty pale. Hind tibiæ red or sometimes in female pale reddish; spines red, with blackened apices.

Length of body, male, 19.2 to 21 mm; female, 26.5 to 31; pronotum, male, 5 to 5.7; female, 7.1 to 8; elytra, male, 3.8 to 4; female, 5.8 to 6; hind femora, male, 13.1 to 14.3; female, 18 to 20.5.

This is the first species of the genus *Bibracte* from the Philippine Islands; it is very probable that *Bibracte backeri* Bolivar (in litt.) mentioned by Bruner[11] is identical with *B. bimaculata*. The new species resembles somewhat two Javanese species, which are also characterized by the strongly abbreviate, scalelike, elytra; namely, *B. diminuta* Brunner von Wattenwyl and, especially, *B. cristulata* Stål; but it differs from them in the shape of the elytra, in the not rugosely punctured and practically smooth

[11] Catalogue 257.

pronotum, in the coloration of the hind legs, and in the presence of a black spot on the elytra. From the known member of the genus *Gerenia* Stål (according to Doctor Willemse this genus is congeneric with *Bibracte*) the new species differs strongly in its scalelike elytra.

Genus EUCOPTACRA Bolivar

EUCOPTACRA CYANOPTERA (Stål).

Eleven males and eight females. This species was described from the Philippine Islands.

Genus CATANTOPS Schaum

CATANTOPS SPLENDENS (Thunberg).

Nine males and five females. A widely distributed Oriental species previously known from the Philippine Islands.

CATANTOPS HUMILIS (Serville).

Two males and four females. Although this is a widely distributed Oriental species it has not been known from the Philippine Islands.

TETTIGONIIDÆ

PHANEROPTERINÆ

Genus MIROLLIA Stål

MIROLLIA CINCTICORNIS Karny.

One male. This species was recorded by Bruner [12] from Los Baños under the same name, but without a description; recently it was fully described by Karny from the same place under Bruner's name.

Genus TAPIENA Bolivar

TAPIENA STYLATA sp. nov. Text fig. 10.

LUZON, Laguna Province, Los Baños, 1 male (*N. Ikonnikov*).

Closely allied to *T. cerciata* Hebard from Mindanao, Philippine Islands, but well separated from it in the structure of the cerci, the subgenital plate, and the very long style. Size large for the genus. Head with densely punctured face, occiput flattened, very feebly convex, with stronger and denser puncturation; fastigium of the vertex very small, strongly narrowing anteriorly, deeply sulcate, broadly triangular, basal part equal in width to the first antennal joint.

[12] Univ. Studies, Lincoln 15 N2 (1915) 82.

Disc of pronotum flat, strongly and densely punctured, posterior part scarcely wider than anterior; lateral lobes quite vertical, forming with a disc a right angle, their depth a little greater than width.

Elytra broad, reaching the apex of hind tibiæ, gradually narrowing to the apex, which is narrowly rounded; sector of the radial vein (Rs) branching on its median point, its base placed distinctly before the middle of elytra. Wings longer than elytra.

Last tergite simple, truncate posteriorly; supra-anal plate small, elongate, roundly triangular, deflexed between basal parts

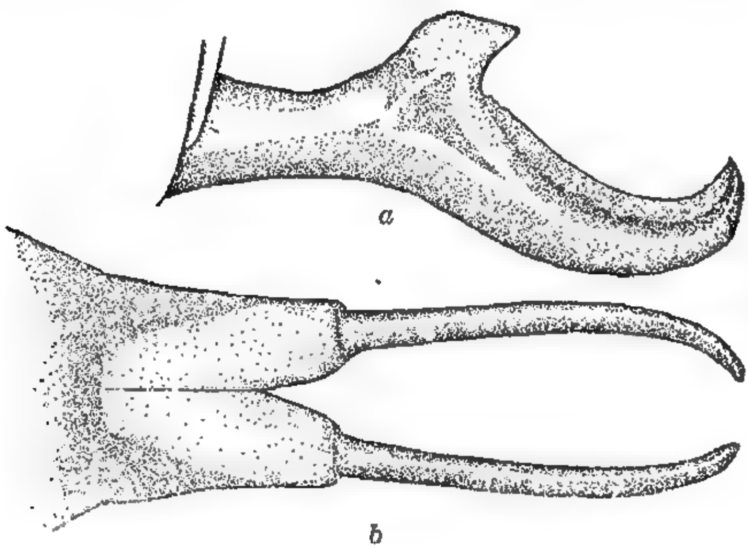

FIG. 10. *Tapiena stylata* sp. nov., *a*, left cercus of male, lateral view; *b*, subgenital plate and style of male, ventral view; greatly enlarged.

of cerci. Cerci large, basal third cylindrical, the other part depressed laterally with rounded lower margin and sharpened and lamellate upper margin; upper margin with a large and broad lamellate appendage placed a little before the middle of cercus; apical part gradually narrowing, its dorsal margin concave, apex sharpened, practically spiniform. Subgenital plate reaching the middle part of cerci, narrowing apically, with a narrow triangular excision on the apex, the branches cylindrical, with very slender and long filiform styli, which are narrowed and incurved apically; the apex of styli extending far behind the apex of cerci. The armature of ventral margins of femora with small teeth are as follows: Anterior femora with four in-

ner, and no outer spine; middle femora with no inner, and one outer spine; hind femora with three or four inner and six outer spines.

General coloration green. Head, pronotum, abdomen, and femora greenish yellow (probably discolored); elytra with some very small and indistinct dark spots in posterior part.

Length of body, 28 mm; pronotum, 6.9; anterior width of pronotum, 43; depth of lateral lobes, 5.2; length of elytra, 41.5; maximum width of elytra, 10.4; length of hind femora, 17.9; styli, 4.

The type is unique.

This easily separated species shows a very close morphologic and geographic affinity to *T. cerciata* Heb.

Genus CASIGNETA Brunner von Wattenwyl

CASIGNETA SPINICAUDA Karny.

One female. This species was described by Karny [13] from Mount Maquiling, Luzon, which is in the vicinity of Los Baños.

Genus PHAULA Brunner von Wattenwyl

PHAULA PHANEROPTERVIDES Brunner von Wattenwyl.

One female. This species is known only from the Philippine Islands.

Genus EUANEROTA Karny

EUANEROTA FURCIFERA (Stål).

Four males and seven females. This species has been recorded only from the Philippine Islands.

Genus DUCETIA Stål

DUCETIA JAPONICA Thunberg.

One male and four females.

PSEUDOPHYLLINÆ

Genus PHYLLOMIMUS Stål

PHYLLOMIMUS DETERSUS (Walker).

One female. A widely distributed Malayan species.

CONOCEPHALINÆ

Genus XIPHIDION Serville

XIPHIDION AFFINE Redtenbacher.

One male.

[13] Philip. Journ. Sci. 18 (1921) 614.

XIPHIDION MACULATUM Le Guillou.

Six females. Two very common and widely distributed species.

AGRÆCIINÆ

Genus CORYPHODONTA novum

Superficially very similar to the genus *Salomona* Blanchard, but not intimately related to it and showing the closest affinity to *Acanthocoryphus* Karny, of Tonkin; from the last-mentioned genus it differs as follows:

Face shallowly impressed-punctate; fastigium of the vertex shorter, not spiniform, slightly longer than its basal width, subequal in length to the first antennal joint. Disc of pronotum with feeble but distinct transverse impression at the hind transverse sulcus. Lateral lobes distinctly longer than their vertical depth, lower margin oblique, with a distinct obtuse angulate excision before lower anterior angle, humeral sinus well indicated. Elytra and wings fully developed, reaching the apex of ovipositor. Lower margin of femora armed with large and small spines; genicular lobes of the anterior and middle femora unispinose on the inner side and roundly produced on the outer side, genicular lobes of hind femora with relatively long spinula on each side. Subgenital plate short, with hind margin truncate.

Genotype.—*Coryphodonta ikonnikovi* sp. nov.

This genus includes also *Acanthocoryphus mindanensis* Hebard, recently described from Mindanao, Philippine Islands,[14] which is closely allied to *C. ikonnikovi* sp. nov., described below.

CORYPHODONTA IKONNIKOVI sp. nov. Text fig. 11.

LUZON, Laguna Province, Los Baños, May 15, 1917, 1 female (*N. Ikonnikov*).

Female.—In general habitus and structure very like *C. mindanensis* Hebard (described as a member of the genus *Acanthocoryphus* Karny) and differing from it in the structure of the vertex and in many other features.

Body robust, a little smaller than body of *C. mindanensis.* Head very large and broad; fastigium of vertex short-conical, apex rounded, dorsal surface armed with a simple relatively small tubercle, in the basal half, a little before the middle of fastigium; occiput not punctured.

[14] Proc. Acad. Nat. Sci. Phila. (1922) 227–229, pl. 18, figs. 10 and 11.

Disc of pronotum flattened, very densely but not coarsely rugulose, hind margin truncate; first transverse sulcus feebly indicated, at the base of the anterior third, the second (principal) sulcus well developed, a little behind the middle of pronotum. Lateral lobes rugulose, with sulci distinct. Elytra extending beyond the apex of hind femora at a distance equal to half the length of hind femora, gradually narrowing apically. Anterior femora moderately heavy, subparallel-sided, lower inner margin armed with a large spine preceded by one or two small spines, followed by gradually decreasing three or four small spines and then a larger spine somewhat before the apex of femora; median femora feebly but distinctly narrowed apically, lower external margin with three large spines of which the middle is the largest, and with one and three small spines between them; hind femora with five or six large spines on the lower outer margin and with a few small spines, none to two, in the intervals between the large spines. Prosternum and middle coxæ unarmed. Subgenital plate very short, transverse, rectangular. Ovipositor unarmed, feebly incurved upwards, dorsal margin of the flattened part straight, lower margin roundly incurved; regularly narrowing and sharpened apically, maximum width on the middle.

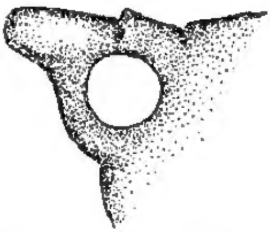

FIG. 11. *Coryphodonta ikonnikovi* gen. et sp. nov., fastigium of vertex of the female type, lateral view, greatly enlarged.

General coloration light brown. Head unicolorous, except lower surface of the fastigium of vertex, fastigium of front, and a small space surrounding the median ocellus, which are olive-green; lower part of the labrum reddish. Disc of pronotum darker than head and lateral lobes. Elytra light brown, with numerous dark spots, especially in the anterior field and along the sutural margin. Legs, abdomen, ovipositor, and antennæ light brown, without a dark color, except antennæ which have some very sparse dark rings, especially in the basal part.

Length of body, 28.5 mm; fastigium of vertex, 1.2; pronotum, 8.5; posterior width of pronotal disc, 5.5; length of elytra, 25; width of elytra, 6.2; length of hind femora, 14.8; ovipositor, 13.3; maximum width of ovipositor, 2.2.

The type is unique.

Besides the difference in the structure of the fastigium of vertex the new species is easily separated from *mindanensis* by its smaller size, the nonpunctured occiput, the shape of the elytra, and the coloration.

Hebard wrote in the description of his *Acanthocoryphus mindanensis* that this species "is widely distinct from *A. brongniarti* Karny described from Tonkin but no characters warranting generic separation can be determined." But the discovery of the second similar species in the Philippine Islands with the same general morphology as *mindanensis* reveals (after a careful comparison of these species with the description and excellent figure of *Acanthocoryphus brongniarti*)[15] many morphological differences, described above, between the Philippine species and the genotype of *Acanthocoryphus*. On the other hand there is a relatively broad geographic separation between *Acanthocoryphus* and *Coryphodonta* gen. nov., which is another good reason for the separation of these two genera.

[15] Revisio Conocephalidarum (1907) 72, fig. 17.

ILLUSTRATIONS

TEXT FIGURES